THE QUARTERLY REVIEW OF BIOLOGY

DECEMBER
1956

Vol. 31 No. 4

Published by
THE WILLIAMS & WILKINS COMPANY
BALTIMORE, U. S. A.

Copyright 1957
THE WILLIAMS & WILKINS COMPANY

THE QUARTERLY REVIEW OF BIOLOGY

FOUNDED BY RAYMOND PEARL

B. H. WILLIER, *Editor*
The Johns Hopkins University

H. BENTLEY GLASS
Associate Editor

CARL P. SWANSON
Assistant Editor

Advisory Board

IRVING W. BAILEY ..... *Harvard University*
G. W. BEADLE ..... *California Institute of Technology*
DAVID R. GODDARD ..... *University of Pennsylvania*
ROSS G. HARRISON ..... *Yale University*
LIBBIE H. HYMAN ..... *American Museum of Natural History*
A. L. KROEBER ..... *University of California*
K. S. LASHLEY ..... *Harvard University*
DANIEL MAZIA ..... *University of California*
CHARLES W. METZ ..... *University of Pennsylvania*
THOMAS PARK ..... *University of Chicago*
ALFRED S. ROMER ..... *Harvard University*
ALEX G. RUTHVEN ..... *University of Michigan*
F. O. SCHMITT ..... *Massachusetts Institute of Technology*
PAUL WEISS ..... *Rockefeller Institute*

Papers to Appear in an Early Number

SYMPOSIUM ON THE EFFECTS OF IONIZING RADIATION ON PLANTS

Arnold H. Sparrow, *Brookhaven National Laboratory*
Solon A. Gordon, *Argonne National Laboratory*
Karl Sax, *Harvard University*
Calvin F. Konzak, *Brookhaven National Laboratory*
James E. Gunckel, *Rutgers University*

Entered as second-class matter January 27, 1926, at the post office at Baltimore, Maryland, under the act of March 3, 1879. Subscription price $6.00 a year ($6.75 outside U.S.A., except Canada. Canada, $6.25) $1.75 a single copy, when available, $.25 postage outside U.S.A.

Made in United States of America

PROCEDURE IN TAXONOMY

THIRD EDITION

Edward T. Schenck and John H. McMasters
Third Edition Revised by
A. Myra Keen and Siemon W. Muller

Perhaps the only work available for beginning students in taxonomy, this revision brings the text up to date and incorporates procedural changes of the past several years. New rulings by the International Commission on Zoological Nomenclature have been added to the appendix. $3.50

HUMAN GENERATION

CONCLUSIONS OF BURDACH, DOLLINGER, AND VON BAER

Arthur W. Meyer

Three historically important studies in the field of human generation, translated into English for the first time and with illuminating comment by Dr. Meyer. The book shows that von Baer's discovery of the mamalian ovum was not promoted by the views of his teachers, Döllinger and Burdach. $3.50

STANFORD UNIVERSITY PRESS
Stanford, California

(In writing to advertisers, please mention the journal—it helps.)

SECTION THREE NOW READY!

A Stereoscopic Atlas of Human Anatomy

By DAVID L. BASSETT, M.D.

In amazing three-dimensional Kodachrome transparencies

Photography by WILLIAM B. GRUBER

Section III. The Upper Extremity $22.50

196 views on 28 View-Master Reels. Seven consecutive dissections per reel. The most ideal way yet found to study anatomy. Compact and easily located slides, plus over 300 pages of descriptive text and illustrations.

Section III includes: 63 magnificent views of the hand; osteology; selected radiographs; exploratory anatomical dissection of the entire upper extremity.

ALSO AVAILABLE

Section I: The Central Nervous System $27.50
34 reels. 238 views. 500 pp. Seven consecutive dissections per reel.

Section II. The Head and Neck $38.50
50 reels. 350 views. 700 pp. Seven consecutive dissections per reel

View-Master Stereoscope	$2.00
Stereoscope with light attachment (uses batteries)	4.00
Stereoscope with light att., transformer and cord (std. AC)	7.00
View-Master S-1 Projector, brilliant 36-inch image, 110–120, AC-DC	44.50
"Stereomatic 500" Projector	119.50

THE WILLIAMS & WILKINS COMPANY

(exclusive agents for the United States, except the 11 Western states)

Mt. Royal and Guilford Aves. Baltimore 2, Maryland

J. W. STACEY, INC.

(exclusive agents for the 11 Western states)

551 Market St. San Francisco 5, Calif.

Published by SAWYER'S, INC.
P.O. Box 490, Portland, Oregon

(In writing to advertisers, please mention the journal—it helps.)

Annals of Human Genetics

(FORMERLY ANNALS OF EUGENICS)

Edited by L. S. PENROSE *with the assistance of*
JULIA BELL, R. A. FISHER, J. B. S. HALDANE, MARY N. KARN, R. R. RACE, J. A. F. ROBERTS AND C. A. B. SMITH

Vol. XXI. Part 2. December 1956.

CONTENTS

Sex-linked ocular albinism in a Dutch family. J. VAN DEN BOSCH AND P. J. WAARDENBURG
The relationship between parental age, birth order and the secondary sex ratio in humans. E. NOVITSKI AND L. SANDLER
The retinae of monovular and binovular twins. R. PLATT AND R. LAWTON
Blood groups in Persian Jews. J. GUREVITCH, E. HASSON AND E. MARGOLIS
Heredity and rheumatic fever. A. C. STEVENSON AND E. A. CHEESEMAN
Effect of migration on some genetical characters in six endogamous groups in India. SATAVAVATI M. SIRSAT
Colour-blindness and the Duchenne type muscular dystrophy. URSULA PHILIP AND J. N. WALTON (with a note on the estimation of linkage. C. A. B. SMITH)
Nail-patella syndrome: evidence for modification by alleles at the main locus. J. H. RENWICK
Hair colour in the infantile Fanconi syndrome. VALERIE COWIE
Sib correlations of weight and rate of growth and relation between weight and growth rate over the first five years. MARY N. KARN
Review

Subscription price $13.50 net per volume.
Single issues $4.50 plus postage.

Issued by the CAMBRIDGE UNIVERSITY PRESS
32 East 57th Street, New York 22, N. Y.

LEARNING AND INSTINCT IN ANIMALS

W. H. THORPE, F.R.S., presents a long-needed synthesis between the different methods of research and points of view—zoological, physiological, and psychological—pursued in the study of animal behavior. Part I deals with the general principles and concepts involved in the study of behavior Part II consists of a series of chapters surveying one by one the part which learning plays in the organization of the behavior of all the principal groups of animals—from Protozoa on the one hand to Mammals on the other. This book makes possible for the student of learning on the one hand and the student of instinct on the other an overall perspective on their joint objective—the understanding of the learning ability of animals. With 9 halftone plates and 82 diagrams. $10.00

THE MICROBE'S CONTRIBUTION TO BIOLOGY

By A. J. KLUYVER and C. B. van NIEL. "The specialist . . . cannot fail to be impressed by the broad view and historical perspective of the authors. This book will be of inspirational value to students in all branches of biology who have some training in biochemistry. . . . Heartily recommended."—MARK H. ADAMS, in *Scientific Monthly*.

(*The John M. Prather Lectures, 1954*) $4.00

Through your bookseller, or from
HARVARD UNIVERSITY PRESS
CAMBRIDGE 38 · MASSACHUSETTS

(In writing to advertisers, please mention the journal—it helps.)

POPULATION GENETICS:

The Nature and Causes of Genetic Variability

Cold Spring Harbor Symposia on Quantitative Biology

Volume XX (1955), 350 + xiii quarto pages, with numerous figures

Authoritative reviews of research dealing with various problems of population genetics presented in 32 papers and edited discussions. Problems considered are: theory of population genetics, theory of quantitative genetics, selection in plants and animals, genetic variability and polymorphism, populations in time and space, and integration of genotypes.

Previous volumes still available: IX (1941) Genes and Chromosomes; XIII (1948) Biological Applications of Tracer Elements; XIV (1949) Amino Acids and Proteins; XV (1950) Origin and Evolution of Man; XVI (1951) Genes and Mutations; XVII (1952) The Neuron; XVIII (1953) Viruses; XIX (1954) The Mammalian Fetus.

Prices: Volumes IX–XV, **$7**; XVI–XX, **$8**. Volumes IX, XV, XVI, XVIII and XX: any two, **$14**; any three, **$19**; any four, **$24**; all five, **$29**.

Address: **BIOLOGICAL LABORATORY, Cold Spring Harbor, N. Y.**

MORE GOLF SECRETS

By H. A. Murray, M.D.

2nd edition

171 pp. 14 figs. $2.50

Dr. Murray's second valuable book on golf analyzes aspects of the game other than the swing. Here is information about stance, ball position, address, grip, putting, chip shot, stymie, ball spin, cut shots, etc. Nothing essential to good golf has been left out.

Also by Dr. Murray—

THE GOLF SECRET

160 pp. 14 figs. $2.50

Anatomical analysis of the golf swing.

The Williams & Wilkins Co.

Mt. Royal and Guilford Aves.
Baltimore 2, Maryland

ECOLOGY

Official Publication of the ECOLOGICAL SOCIETY OF AMERICA
Continuing the Plant World

Editors:
Edward S. Deevey (Zoology), Yale University **W. D. Billings** (Botany), Duke University

Vol. 38, No. 1 *Table of Contents* January, 1957

Germination-regulating mechanisms in some desert seeds. IV. *Atriplex dimorphostegia* Kar. et Kir. ... *Dov Koller*
Evidence of the presence of an edapho-biotic factor in the problem of serpentine tolerance ... *T. M. Tadros*
The classification of lowland swamp communities in northeastern Papua ... *B. W. Taylor*
Establishment of vegetation on sand flats along the Hudson River, New York. II. The period 1945–1955 ... *Rogers McVaugh*
The York Woods, a case history of forest succession in southern Wisconsin ... *Robert P. McIntosh*
Local climate in the Harvard Forest ... *Stephen H. Spurr*
Symposium on applications of ecology.
Applications of ecology in forest management ... *H. J. Lutz*
Application of ecology to range management ... *David F. Costello*
The application of ecology to wildlife management ... *Paul Hickie*
The contribution of ecology to wildland soil management ... *Earl L. Stone, Jr.*
Applications of ecology to public health ... *Marston Bates*
Applications of ecology-concluding statement ... *Lincoln Ellison*
Studies on the critical thermal maxima of salamanders ... *Richard G. Zweifel*
Ecology, maturation, and reproduction of *Thamnophis sauritus proximus* ... *Donald W. Tinkle*
The food of Jefferson's salamander, *Ambystoma jeffersonianum*, in Rondeau Park, Ontario ... *W. W. Judd*
Seasonal population fluctuations of mites in desert wood rat nests in central Utah ... *J. F. Howell, D. M. Allred, and D. E. Beck*
Distribution, growth, and availability of juvenile croaker, *Micropogon undulatus*, in Virginia ... *Dexter S. Haven*
A study of the diets and nutritional preferences of tropical species of *Drosophila* ... *A. Brito da Cunha, A. M. El-Tabey Shehata, and W. de Oliveira*
Sociality and sparse populations ... *J. R. Philip*
A study of the invertebrate bottom fauna of Greenwich Bay, Rhode Island ... *Alden P. Stickney and Louis D. Stringer*
Abundance of the hard clam, *Mercenaria mercenaria*, in relation to environmental factors ... *Harry W. Wells*
Pleistocene climate and the fauna of Burnet Cave, New Mexico ... *Keith F. Murray*
Tracing vole movements by radioactive excretory products ... *Lotus Simon Miller*

NOTES AND COMMENT

Orders should be placed with

Duke University Press

College Station, Box 6697 Durham, North Carolina

(In writing to advertisers, please mention the journal—it helps.)

VOL. 31, NO. 4 December, 1956

THE QUARTERLY REVIEW *of* BIOLOGY

CELL DIVISION

II. A THEORETICAL APPROACH TO CHROMOSOMAL MOVEMENTS AND THE DIVISION OF THE CELL*

By NORMAN G. ANDERSON

Biology Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee

"It is only in the light of some theoretical scheme that we can decide what are the most important questions to ask, and in what directions we should look for further insight into the fundamental nature of the mechanisms with which we have to deal." C. H. Waddington, 1954.

INTRODUCTION

IN THE first paper in this series it was shown that the early development of the surface of the earth, as it is thought to have occurred, would have favored the development of colloidal systems bearing a net negative charge, and that the compounds available for primitive metabolism would have been predominantly organic acids, amino acids, and nonvolatile organic bases. The origin of a division mechanism in primitive living systems was considered to lie in cyclical changes in the rate of formation of nucleic acids and proteins resulting from differences in the diffusion rates of the precursors of the two types of macromolecules. Cyclical changes in the ratio of charges on cellular colloids were proposed as the fundamental mechanism of cell division. Further considerations showed that a great part of the experimental data on the initiation of cell division was compatible with this idea. The condensation of chromosomes at prophase was shown to be most easily explained in terms of a masking or neutralization of negatively charged groups, i.e., a change in the balance of positive and negative charges associated with macromolecules.

In this paper the proposed original mechanism will be related to other aspects of cell division. As in the first article (Anderson, 1956), no attempt is made to present either a review on cell division or an exhaustive bibliographical presentation. For these, the reader is referred to Schrader (1953), Hughes (1952), Ris (1949, 1955), and Mazia (1956).

STRUCTURE AND MOVEMENT

It is self-evident that the physical properties of most material substances are related to the degree of interaction of their constituent molecules. Movement may therefore be considered as evidence of changes in the degree or type of interaction. Although a case has been made for the movement of microscopic structures and for the alteration of cell shape by diffusion drag forces (Rashevsky, 1938, 1939; Landahl, 1942a, b, c, d), the movements observed during cell division are most easily explained on the basis of the physicochemical properties of gels and the formation of contractile fibrils of colloidal dimensions. The latter concept, which originated in van Beneden's suggestion in 1883 that chromosomal movements are paramuscular, has been extended with each advance in knowledge of the nature of muscular contraction. A discussion of

*Under USAEC Contract No. W-7405-eng-26.

some of the possible mechanisms by which contractile systems may be formed in cells is of interest. Although protein will be considered as the chief constituent, other substances, such as nucleic acids and acid polysaccharides, may also be involved.

Artificial protein fibers, which have been given the generic name *Azlon*, have been widely investigated because of their commercial significance (see review by Lundgren, 1949). The essential steps necessary to form such fibers are (1) dissociation of the native corpuscular configuration to form dispersed flexible chains, and (2) alignment of the chains in quasiparallel fashion under conditions favoring the formation of linkages between the side chains to give a fibrous protein characterized by free chain segments interspersed between crystallite regions and regions of mesomorphic order. A wide variety of denaturing agents, including heat, formaldehyde, urea, and alkali, has been used. Alignment of the unrolled molecules is generally achieved by laminar flow through small orifices and by stretching of the wet fibers. It should be emphasized that energy must be supplied for the molecules to be aligned.

Numerous attempts have been made to apply similar principles to fibril formation in cells. Frey-Wyssling (1953), for example, suggested that "the globular macromolecules must simply denature to give expanded chains which aggregate laterally." The native, rolled up, folded, or coiled configuration of a polypeptide chain is much more probable than the unrolled or extended configuration. The energy required to unfold a protein partially may be small, but no mechanism is known that will supply this energy in the cytoplasm and hold the unrolled polypeptide chains extended during lateral aggregation. The unrolling or denaturation of protein at air-water interfaces, which is often mentioned, has no counterpart in the fluid cytoplasm. It does not appear likely, therefore, that the sol-gel changes in the cell are an expression of the formation of contractile fibrils formed from interlinked unrolled polypeptide chains.

In my opinion, emphasis upon the application of the work of Waugh, of Joly and coworkers, and of Zbarskii and Perevoshchikova to cellular physiology is long overdue. In contrast to the drastic alterations necessary to produce artificial protein fibers from denatured proteins, these workers have demonstrated the formation of thread-like particles, often many thousands of Angstroms long, by the end-to-end aggregation of globular molecules without gross denaturation. This has been shown to occur in the first stages of sol-gel transformation of gelatin (Joly, 1949a), in the thermal denaturation of horse serum albumin (Joly, 1949b; Joly and Barbu, 1949, 1951; Barbu and Joly, 1950), human serum albumin (Kleczkowski, 1949) and egg albumin (Foster and Samsa, 1950, 1951a, b; Jaggi and Waugh, 1950), in insulin gelation (Waugh, 1941, 1946; Farrant and Mercer, 1952), in the association of fibrinogen induced by thrombin (Waugh and Livingstone, 1951), and in the formation of contractile fibers by the combination of basic and acidic proteins (Zbarskii and Perevoshchikova, 1948, 1951a, b). Excellent agreement between data obtained by flow birefringence, electrophoresis, ultracentrifugation, and electron microscopy has been obtained by Barbu and Joly (1953), demonstrating the reality of the aggregation of globular proteins.

Factors governing the stability and the aggregation of colloidal particles have been examined in considerable detail (Verwey and Overbeek, 1948; Kruyt, 1949), chiefly in lyophobic systems. The distinction between lyophobic and lyophilic colloids is not a sharp one, however, and all gradations between the classic lyophilic and lyophobic colloids exist. Many of the properties of each may exist in the same colloid particle.

Rees (1951) has developed a theory of directed aggregation in colloidal systems based on the observation of Henri in 1906 (cited by Rees, 1951) that rubber latex particles aggregated in linear arrays during gelation and on the suggestion of Usher (1929) that a single particle would aggregate with a close pair of particles to form a linear rather than a triangular arrangement, since a linear configuration required the approaching particle to overcome the residual forces of only one particle of the pair. Rees calculated the contours for equal potential energy of interaction for a system in which there is a substantial potential energy maximum for the interaction of two particles (a stable suspension). It was assumed that the interaction forces could be treated as the vector sum of the interactions of single particles with each component of the biparticle. The results for such a system are shown in Fig. 1. It is evident that the interacting particle encounters a lower potential barrier for an approach along the axis of the two particles than normal to it. In such a system, a comparatively slow aggregation of an initially stable suspension may be produced by a reduction in the surface potential or by an increase in the thermal energy of the particles themselves.

Barbu and Joly (1953) have presented a detailed mathematical treatment of the linear aggregation of molecules the size of proteins. They concluded that in aggregation after heating or other mild denaturation, denaturation proceeds by the releasing of groups initially coupled inside the molecule. This allows the formation (on particular areas on each molecule) of weak intermolecular bonds such as hydrogen bonds, salt bridges, or weak van der Waals forces.

The principle of linear aggregation of colloids finds numerous applications in biological systems. The polymerization of globular actin (G-actin) has been studied by many workers. It again appears to involve the direct aggregation of globular molecules (Rozsa, Szent-Györgyi, and Wyckoff, 1949). The linear aggregates or fibrils often appear to reach a characteristic length (Barbu and Joly, 1953), perhaps illustrating a self-limiting property suggested by Rees (1951).

The possible steps in the formation of large structures from simple molecules, as given by Rees, are: (1) the formation of small macromolecular aggregates of specific size and shape (in this case, the synthesis of proteins); (2) the linear aggregation of small macromolecular units to form microfibrils; (3) the lateral association of microfibrils to give so-called "tactoid" regions; (4) the consolidation of these regions to give closely packed "tactoids"; and (5) the lateral association of these "tactoids" to give larger fibrous units.

Much has been written about the possible relation between tactoids observed in virus suspensions and the formation of the spindle (Bernal, 1940). It was originally thought that in such suspensions the ratio between attractive and repulsive forces varied with the distance from the particle in such a manner that an optimum of attractive forces existed at some distance from each particle. Repulsive forces predominating closer to the particle prevented particles from a closer approach (Bernal and Fankuchen, 1941). In dried tobacco mosaic viruses, the distances between parallel particles was 152 A. With the addition of increasing amounts of water, the particles moved farther and farther apart, until at 87 per cent water they were separated by 450 A. This was taken as proof of the existence of long-range forces.

The theories that attempt to show that two charged colloidal particles will attract each other at large interparticle distances owing to an overlapping of ionic atmospheres have been shown to be unlikely (Oster, 1950); and, furthermore, it

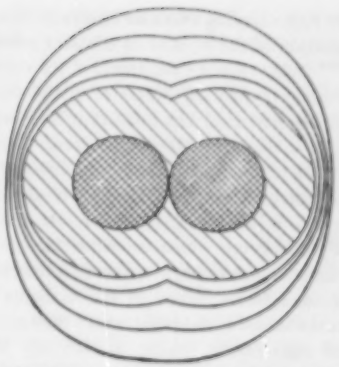

FIG. 1. POTENTIAL-ENERGY CONTOURS WHERE THE SURFACE POTENTIAL IS SMALL

The potential energy is negative throughout. (From Rees, 1951).

does not appear that the conclusions of Bernal are justified by the experimental data that he cites. Bernal does not stress that tactoids, like coacervates generally, exist in equilibrium with a dilute phase. The tactoid goes back into "solution" in the presence of pure solvent. This characteristic alone renders the whole concept of long-range attractive forces based on virus studies suspect, since it implies that the most probable condition is a random distribution, and not long-range orientation.

In an excellent study and discussion of phase formation in virus solutions and of the problem of long-range forces, Oster (1950) concluded that the forces responsible for tactoid formation are *repulsive*, in direct opposition to the concept of Bernal. Oster pointed out that if rod-shaped particles are crowed, i.e., do not have a free sphere of rotation, the orientation of any one particle will determine the orientation of its neighbors so that ordering will set in. In a virus suspension, such ordering results in an area of more efficient packing that, because of its increased density, will fall to the bottom of the solution. Although the tactoid phase may have decreased entropy, this is offset by the increase in entropy in the random or non-ordered phase. No added energy or long-range forces are required. As a first approximation, it would be expected that two phases would be formed when the thermodynamically effective volume of each particle exceeds the volume of solution available per particle. This Oster finds to be true.

The repulsive forces per square centimeter

between rods carrying a similar charge are found to be a function of the squares of the zeta potentials and $e^{-2\kappa R}$, where κ is the reciprocal of the thickness of the ionic double layer and R is the distance between the particles. The important conclusion to be drawn is that with the tactoid-forming viruses the force *is* repulsive and that it decreases rapidly with distance. The range of repulsion becomes even shorter as κ becomes larger. As a result, the addition of electrolytes, which decreases the thickness of the ionic double layer, also shortens the range of the repulsive forces. Although the repulsive forces may be decreased to the point where they no longer prevent aggregation, owing to van der Waals–London attractions or other forces, no interplay of forces was found that allowed attractive forces to predominate at intermediate distances while repulsive forces were dominant at shorter ranges. Oster has, therefore, been able to explain the formation of tactoids in terms of geometrical considerations without recourse to the concept of long-range attractive forces.

Quite apart from the forces involved in tactoid formation, the point of interest here is simply a question of whether the spindle resembles a tactoid. Electronmicrographs of dividing cells indicate that the spindle is not composed of particles the size and shape of viruses (Selby, 1953). The question is then whether the principles that result in the formation of tactoids in virus suspensions also produce similar configurations when the anisotropic particles have a cross section in the range of certain globular proteins. For the purpose of this treatment, it is assumed that beaded chains produced by the alignment of globular proteins will, when a critical concentration is exceeded, separate into a soluble dilute phase and a relatively condensed phase showing some of the properties ascribed to tactoids. These include parallel orientation of the fibrils and variable interfibril distance, depending on the ionic atmosphere or surface charge of the fibril. Note that nothing has been said about the mechanism that would tend to keep the fibrils straight instead of randomly coiled.

The reason for including tactoid formation here is simply that it is a possible mechanism for decreasing the entropy in a system of anisotropic fibrils or chains to produce parallel orientation. Such orientation is a necessary step in the formation of long, contractile fibrils. Once a predominantly parallel orientation is obtained, formation of regions of mesomorphic order could contribute to the formation of gel fibrils. The application of the colloid chemistry of tactoids to the spindle will be described in a subsequent section.

If it is assumed that mechanisms for producing fibrous systems exist, there is a question whether they will contract. The preparation and contractility of artificial actinomyosin fibers is well known, but the problem of a similar contractile mechanism in cells has received less attention. Zbarskii and Perevoshchikova (1948) observed that proteins isolated from nuclei with 0.24 *M* HCl and precipitated by saturation with NaCl yielded a viscous solution when redissolved in very dilute HCl. When the solution was injected into water, fibers were formed that contracted sharply with adenosine triphosphate (ATP) (Table 1). The proteins were originally described as histones. However, further work (Zbarskii and Debov, 1948, 1951; Zbarskii and Perevoshchikova, 1951a, b) demonstrated that the acid extract of freshly isolated nuclei from many sources contained trytophan. Repurified histones prepared from 1 *M* NaCl extracts of the same nuclei contained no tryptophan. The contractile material was a combination of histone and an acidic protein. A number of acidic proteins could be substituted for those found in the nucleus. Zbarskii and Perevoshchikova (1951a, p. 123) concluded that "the contractile properties of nuclear proteins play a very important role in the mechanism of mitosis and, in particular, in such of

TABLE 1

Contraction of "histone fraction" fibers of liver cell nuclei under the influence of varying concentrations of Na_4ATP

	Final concentration of ATP (molarity)						
	7.7×10^{-3}	5.0×10^{-3}	2.5×10^{-3}	10^{-3}	5×10^{-4}	2.5×10^{-4}	10^{-4}
Contraction of fibers (per cent of original length)	48*	50*	45*	43†	37†	34†	22‡

* Very rapid contraction.

† Contraction rapid, but with preliminary stirring of mixtures for more even distribution of ATP.

‡ Contraction after 5 minutes.

(From Zbarskii and Perevoshchikova, 1951a, p. 117).

its phases as the formation of metaphase chromosomes and the contraction of the stretched fibers of the spindle. It is also possible that in the cell nucleus there form or become detached from the nucleic acids (probably by an enzymatic process) polyphosphoric nucleotides whose action on proteins of the cell nucleus may be the same as that of ATP. Such an effect of nucleoproteins can be connected with the actuating mechanism of mitosis."

The author first became interested in this field when it was observed that the addition of basic dyes to rat liver breis produced microscopically observable fibrils (Fig. 17 in Anderson, 1949). Further work showed that protamine and other basic substances also produced numerous fibrils, many at the limits of resolution of the light microscope (Anderson, 1951), direct evidence thus being provided that substances are available in tissues for forming fibrils in the presence of polybases.

Rybak (1950) and Joly and Rybak (1950) have also suggested that basic proteins may combine with other proteins to form the achromatic spindle. Evidence based on birefringence of flow was presented to show that microfibrils could indeed be formed in model systems. The fundamental notion of this mechanism for producing fibrils in the cytoplasm appears to have arisen independently in three different laboratories. The formation of linear aggregates of cytoplasmic proteins, however, does not in itself mean that the aggregate will contract.

The molecular basis of contractile mechanisms is under intensive investigation. The evidence for electrostatic systems has been reviewed by Katchalsky (1954), who states, "the driving mechanisms of living matter are always biogels of pronounced polyelectrolyte nature, varying in type and organization. Different organisms utilize various gel mechanisms for their motility; the amoeboid movement is based on progressive sol-gel transformation, the movement of plants is founded on reversible swelling and shrinkage of protoplasm while the great majority of higher animals and many protista use an intricate and very effective contractile-gel mechanism." It is interesting that myosin in the presence of monovalent salts is isoelectric at pH 5.4; whereas in the presence of Ca^{++} or Mg^{++} in very low concentrations, the molecule behaves as a basic protein, remaining positively charged up to pH 9. The actinomyosin complex in the presence of divalent cations, therefore, may be considered as a complex of oppositely charged molecules.

The picture, on a molecular level, of the majority of current theories is one of a long-chain molecule or series of molecules held in an extended or stretched condition by virtue of the net charge on the chain. If the charge is altered in such a manner as to decrease the repulsive forces along the chain, Brownian movement returns the extended molecule to a coiled, kindled, or contracted and also more probable state. Theories pertaining to this field have been reviewed by Wilkie (1954), Weber (1955), and by Morales et al. (1955). The difficulty appears to center around the manner in which ATP or some other high-energy compound is involved in alteration of the net charge on the extended molecule. There is no doubt, however, that polyelectrolyte gels can be made to function as mechano-chemical engines of high efficiency (Katchalsky, 1954).

In the production of fibrils composed of globular molecules linearly arranged as the ultimate contractile elements in the cell, emphasis has been laid on mechanisms that would involve only small changes in cell colloids, such as changes in the nature of the surface charge. This is in keeping with the concept that cell function is carried on with an economy of materials and mechanisms. Alternative mechanisms, such as the blood-clotting-like mechanism proposed by Heilbrunn, would require (1) activation of a proteolytic enzyme, (2) degradation of soluble molecules to form gels or "clots," and (3) the eventual digestion of the clot.

A number of doubts have arisen about the electrostatic theory (Weber, 1955; Flory, 1957). Changes in pH that should alter surface charges enough to produce contraction do not appear to do so. Other objections, based on the difficulties produced by the salts present in cells and the fact that the repulsive forces would not only affect segments of the molecular fibril but would force different fibrils apart and produce a nondirectional swelling, have been put forth (Flory, 1957). Flory proposes that the extended state of molecular fibrils is maintained by crystalline areas involving parallel strands. If a strongly charged substance is attached to the strands, crystallinity can no longer be maintained; and the strands revert to a more random, amorphous condition (contract). This concept avoids a number of difficulties inherent in electrostatic theories and possesses an appealing simplicity.

Weber (1955) has summarized the evidence for the belief that all vital contraction of cell parts is

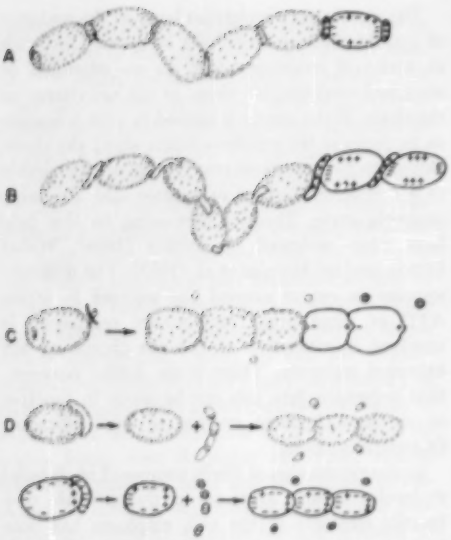

FIG. 2. MECHANISMS FOR ALTERING THE SURFACE CHARGE ON NEGATIVELY CHARGED PROTEIN MOLECULES TO FORM LINEAR AGGREGATES

In A, protein molecules with a fairly symmetric distribution of charge are interlinked with polycations (shown as elongated particles) to give a chain that does not have a pronounced predominance of either positive or negative charges on its surface. In B, polycations interlink proteins having a highly asymmetric distribution of charge so as to give a positively charged chain. In C, a positively charged area on one end of the structure-forming molecule is prevented from interacting with oppositely charged areas on the same species of molecule by the presence of an additional charged group. Removal of this group allows the interaction to occur. In D, interaction between oppositely charged areas on the same species of molecule proceeds after a prosthetic group such as RNA is removed from a negative area on the molecule by depolymerization.

similar, whether in dividing cells, smooth and straited muscle cells, or flagella. Glycerol-extracted models have been used to demonstrate movement in all these, upon the addition of proper concentrations of ATP. Expanded fibroblast models contract (Hoffmann-Berling, 1954a; Hoffmann-Berling and Weber, 1953), and the equator of telophase models constricts into a very narrow bridge (Hoffmann-Berling, 1954b, c, 1955).

Unfortunately, the state of molecular muscle physiology does not now provide a satisfactory molecular model or an isolated actinomyosin particle that exhibits an unequivocal active change in length solution (Weber, 1955). In attempting to apply concepts derived from muscle physiology to the mitotic apparatus, one is faced with the further problem of either assembling this apparatus during prophase, providing for its proper function, and then dissembling and storing it in its entirety for the next division, or else of synthesizing and destroying it.

The mechanism proposed for intracellular formation of fibrils, and several forms that it may take, are summarized as follows. In the simplest instance (Fig. 2, A), a small polycation, of which protamine will serve as a general example, binds other protein molecules to form a beaded chain. The charge on the chain may be predominantly positive or negative in this model, depending on the distribution of charge between the two molecular species. If the distribution of charge is highly asymmetric on the proteins interlinked by polycations, then the over-all charge may be strongly positive (Fig. 2, B). The chain shown in A could form fibers by virtue of crystallization of segments of chains parallel to one another. The second, or B type, could form electrostatically extended fibrils (Kuhn et al., 1950; Kirkwood and Monroe, 1941) that could be cross-linked by the small amount of ribonucleic acid (RNA) or acid polysaccharide present. The absorption of sufficient ATP on the type-A fibrils could lead to contraction of the type discussed by Flory (1957), and the type-B fibrils could contract when sufficient ATP had been absorbed to discharge the chain.

Further refinements are shown in C and D of Fig. 2. In C, the chain is pictured as being formed by complementary molecules that have a single positive and a single negative charge at adjacent points in the complementary areas. (Other charged groups would be present but would not be important for formation of the complex.) A single additional charged group, such as a phosphate group, in one of these areas could prevent polymerization; but removal of the group would allow polymerization to proceed. Similar effects may be obtained if one of the charged groups necessary to the interaction is masked. The mechanism in Fig. 2, D allows opposing charged areas on the fibril-forming proteins to be unmasked by the depolymerization of a prosthetic molecule such as RNA.

All these mechanisms are similar in that they result in fibril formation through the interaction of oppositely charged areas. The forms of the mechanism shown in Fig. 2, A and B are considered more likely to be the original forms of which C and D are considered as possible refinements. It is of interest in connection with model D that negative

charges are removed when fibrils are formed from fibrinogen, the removal thus altering the electrostatic charge pattern on the molecule in the manner postulated here (Lorand, 1954).

Examples of structure formation mediated through weak coulombic forces are available in a number of biological materials. For example, in the vitreous humor, hyaluronic acid and protein, neither of which can fully account for the high viscosity, have been shown to interact electrostatically to produce the observed viscosity (Woodin and Boruchoff, 1955).

THE LIABILITY OF CELLULAR ORGANIZATION

Evidence will now be reviewed for the idea that the cell is composed of a series of colloidal aggregates that, though held together by a wide spectrum of forces, are nevertheless sufficiently liable to be considered as in equilibrium with either smaller complexes or free colloidal particles in solution. The implications of this concept for cell division will also be discussed.

The classical work of Bungenburg de Jong and his coworkers on coacervates (Kruyt, 1949) has emphasized that a coacervate exists in equilibrium with a more dilute solution of the same constituents. The equilibrium may be established only very slowly, and the equilibrium concentration of the dilute phase may be very low. In application of the concept to cellular structures, the objection has been that these are fairly stable in solution. Closer examination, however, suggests that this may not be so. Actually, it appears that the cell contains a wide variety of aggregates that slowly disaggregate when placed in large volumes of solution.

Soluble aggregates

Perhaps the first evidence for a soluble tissue molecular aggregate was the finding by Sorof and Cohen (1951) that material could be reversibly shifted between two electrophoretic peaks in rabbit liver soluble protein preparations by alternate aerobic and anaerobic incubation. Work in this laboratory with rat liver soluble proteins has shown that, in veronal buffers at pH 8.5, a complex disaggregates in the electrophoresis cell, with precipitation of one component (Anderson, 1957). Further evidence for formation of a complex is afforded by the marked changes observed when similar preparations are studied at various pH's. The enzymes of the pentose cycle also appear to form a soluble complex or cluster, since all the enzymes involved sediment together (Newburgh and Cheldelin, 1956). During the isolation of enzymes from crude extracts, it is not infrequently observed that the enzyme activity is widely distributed among various electrophoretic fractions. However, when preliminary salt precipitation or other procedures that may break up soluble complexes have been performed, the activity is then often found in one peak. It is of interest also that myosin in dilute solutions breaks up into several fragments (Joly, Schapira, and Dreyfus, 1955). The well-known instability of many purified enzymes in dilute solution may mean either that they are stabilized by formation of a complex or that they are composed of subunits that dissociate upon dilution.

Soluble complexes are believed to be of central importance in the economy of the cell, for the following reasons. First, the activities of soluble enzymes may be regulated by the degree to which they are aggregated with other enzymes to form complexes. If the complex contains the enzymes that catalyze a chain of reactions, these enzymes will be able to function more efficiently in the presence of enzymes catalyzing the destruction of intermediates than if the enzymes of the complex were free and separate in solution. Since the formation of complexes may be responsive to a whole spectrum of changes (temperature, pH, electric currents, ionic strength, specific ions, hydrostatic pressure, dielectric constant), the mechanism can serve as an effective transducer (in the sense used in electronics) to produce chemical, electrical, and ultimately mechanical responses to these variables.

Second, soluble complexes may serve to solubilize and transport molecules of limited solubility. The importance of this lies in a possible mechanism for cell-membrane formation (Anderson, 1957). If the solubilizing molecule has a different electrophoretic mobility from that of the molecule that it helps to keep in solution, the former may move away from the latter in an electrical field. Since the complexes are labile, the solubilizing molecules remaining attached to the relatively insoluble ones will be swept away as soon as they dissociate. The result will be that a precipitate, possibly in the form of a membrane, will occur wherever a potential gradient exists. It has been shown (Anderson, 1957) that the so-called "current of injury" that occurs in torn cells flows in the proper direction to account for the formation of a new membrane where the damage occurs.

Third, the soluble complexes, if in the form of

linear aggregates, will have a considerable effect on the physical properties of the cytoplasm. Since changes in viscosity occur with little change in the total concentration of substances in the cell, it is evident that aggregation of particles already there must account for the changes in consistency observed. Although particles up to the size of microsomes may well become involved (or entangled), the fundamental change is more likely to be on the molecular level. Monné (1948) and Runnström (1949, 1955) have demonstrated the reversible formation of cytoplasmic fibrils in response to hypertonic solutions and azide. They consider them to be composed largely of microsomes.

The soluble complexes are also considered as intermediates in the formation of many cellular structures. This is in keeping with the concept that the cytoplasm is a labile system in a state of *dynamic equilibrium*.

Structural complexes

The formed elements of the cell include in their fabric such a variety of intermolecular linkages that we find it hard to decide exactly what constitutes a nucleus or a mitochondrion. From the large literature on isolated cell components, only a few citations are necessary. The amount of protein found in isolated nuclei depends on the method of isolation (Stern and Mirsky, 1955; Hale and Kay, 1956). Since the original conclusion that the nuclear envelope is permeable to large molecules (Anderson, 1953a) has been supported in isolated nuclei (Anderson and Wilbur, 1951; Anderson, 1953a, b; Holtfreter, 1954; Stern and Mirsky, 1953), in electron micrographs (Bahr and Beermann, 1954; Watson, 1955), and in intact cells (Brachet, 1956), it appears that a good share of the proteins present in the nucleus of the intact cell are free to diffuse in and out, and that these may be in equilibrium with molecules adsorbed on the nuclear gel-work. The proteins of the microsomes have not been extensively characterized; but again, some of these are removed by increasing the ionic strength (Dallam, 1955) or by the use of mild detergents (Littlefield, Keller, Gross, and Zamecnic, 1955). Perhaps the most interesting cytoplasmic structures from this point of view are the mitochondria, which in simple salt or sucrose solutions swell and may lose a considerable amount of material. This can be partially prevented by the use of chelating agents, ATP, or by proteins or other high-molecular-weight substances. It appears, therefore, that mitochondria tend to dissolve slowly. The ease with which enzymes or other proteins may be removed from mitochondria varies greatly. Catalase, which has most often been found about evenly distributed between the mitochondria and the freely soluble proteins, is almost entirely on the mitochondria when these are isolated in colloid-rich solutions (Greenfield and Price, 1956). Part of the enzymatic complement of heart mitochondria may be isolated by a simple *p*H change. The enzymes that catalyze the oxidation of succinate and reduced diphosphopyridine nucleotide (DPNH) by molecular oxygen are then found associated in a complex particle that has been termed the "electron transfer particle" by Mackler and Green (1956).

Lability similar to that seen in vitro is widely observed in vivo. Starvation can deplete all cell structures of protein, and pathological changes can produce a wide variety of alterations. Of special interest is the sensitive responsiveness of mitochondria that has been stressed by Cowdry (1918). These structures can exhibit marked changes in form in response to heat and cold, starvation, anesthetics, and numerous poisons, and to vitamin deficiencies, endocrine imbalance, and anoxia (see Roberts, 1949). The results have been considered as caused by "functional hypertrophy" (Guillermond, 1934), changes in cell hydration (Kater, 1937), alterations in the physical state of ground cytoplasm as expressed in the glucose-glycogen equilibrium (Clarke and Hair, 1932), or possibly as expressing the utilization of material stored in the form of mitochondria (Bensley, 1947). Of greatest interest is the idea that mitochondria are complexes precipitated from a saturated cytoplasm (Guthrie, 1925). Roberts (1949) concluded that the granulation of mitochondria in response to various experimental methods can be interpreted as an expression of an alteration of normal cellular metabolism. Neither biochemical studies nor electron micrographs do justice to mitochondrial lability.

Many of the changes observed in vivo are suggestive of those observed in vitro. It is significant that the latter may be partially prevented by the addition of high-molecular-weight substances, which would tend to slow down dissolution and which may even form a complex with the substances of the mitochondrion.

Rhythmic changes in the number of mitochondria have been reported during cell division (Chèvremont and Fréderic, 1951; Agrell, 1955). Many of them appear actually to *dissolve* during this process.

The ability of various cell components to be

isolated and studied biochemically in no way counteracts the concepts of labile unquilibrium systems stressed here. This is true for the following reasons. (1) Equilibria in colloid systems are often established very slowly. For isolation of cell particulates, conditions are generally adjusted to further slow down the establishment of equilibria. During the isolation of miotchondria, for example, work is carried on as rapidly as possible and at low temperatures. Also, the particles are not subjected to extreme dilution, but are handled as fairly concentrated suspensions, thus minimizing their dissolution. (2) The equilibrium may be shifted very far in one direction, for example, toward the formation of structure. One does not generally work with breis or brei fractions for more than an hour or two at 37°C. because of the rapid changes that occur. Although these changes can be lumped under the term "autolysis," the question why the changes did not occur in the living cell is still a mystery. The simplest explanation is that structures once "intact" by virtue of their being in equilibrium with a certain concentration of dissolved constituents under controlled conditions of *p*H, salt concentration, intermediary metabolite concentration, and oxygen tension are, in a brei, approaching a different, possibly more self-destructive, equilibrium.

Since an equilibrium may be shifted very far in one direction, almost all of a particular substance may be found in solution or in a particle. However, in the long-term economy of the cell, the very existence of an equilibrium may be of great importance. It certainly accounts for the finite turnover rates of *all* proteins of the cell yet examined, even those of nondividing cells.

In the numerous reviews on the biochemistry of isolated cell organelles (Claude, 1948, 1949; Bradfield, 1950; Dounce, 1950, 1954; Hogeboom, 1951; Potter, Recknagel, and Hurlbert 1951; Schneider and Hogeboom, 1951, 1956; Holter, 1952; Lang, 1952; Schneider, 1953; de Duve and Berthet, 1954; Hogeboom and Kuff, 1955), the nonuniformity in the distribution of enzymes is usually stressed. Certain enzymes are listed as mitochondrial, others as microsomal or soluble, and a few are considered as nuclear. These findings have contributed greatly to our understanding of the biochemistry of cell function. However, the concept is often tacitly assumed and occasionally stated that there *should be* a specific place for each enzyme. It is not my belief that the cell is "the best possible cell, with a place for everything and everything in its place." Rather, the cell as we now know it represents a solution by evolution of a number of problems *some of which cannot be ideally solved simultaneously*. The more important conclusion to be drawn from studies on isolated cell components is that *few instances of apparent exclusive localization exist*, and even with these the total absence of activity in any particular fraction is difficult to demonstrate. One can only set an upper limit for the activity; i.e., the activity is not greater than about 1 to 5 per cent of that found in another fraction.

Additional evidence for the occurrence of the same building blocks—but in different ratios—in all cytoplasmic fractions is provided by serological studies that uniformly show that extensive cross-reactions occur (Arnesen, Goldsmith, and Dulaney, 1949; Dulaney et al., 1949; Malmgren et al., 1951; Schechtman and Nishihara, 1955; Horn, 1956).

Exclusive localization of substances such as proteins (i.e., a nonequilibrium system) could occur only if the cell were completely panmeristic in the sense that Hertwig used the term, i.e., if every persistent part of the cell is self-perpetuating by the process of growth and division. This is obviously not true, and any model of the cell must allow for the migration, on the basis of the available data, of most large molecules in the cell away from the sites of their synthesis. Some mechanism must therefore exist for moving them and assembling them into various cytoplasmic structures. Although a system can be postulated in which each substance synthesized undergoes a complex series of enzyme-mediated changes resulting in the formation of structure, such a system would not so easily exhibit the salient characteristics of the cell, viz., growth, responsiveness, and extreme lability.

The importance of lability lies in (1) the ability of labile structures to grow or diminish when the supply of their constituents in solution changes; (2) the control or "feed back" inherent in an equilibrium system, which dispenses with any separate mechanism for transmitting "information" about structure to synthetic sites; (3) the ability of new complex-forming molecules to find their way into existing structures altering their form, size, or function (i.e., differentiation can occur); and (4) most important for the present discussion, the possibility that many of the constituents of several cell structures are identical.

It is unnecessary to postulate any new intermolecular specificities to account for the condensation of soluble or solubilized molecules into

structure. Serology has demonstrated a variety of these ranging from exquisite selectivity, which often leads to the formation of complexes that are difficult to dissociate without denaturing the proteins involved, to other complexes that can be demonstrated in solution only by biophysical methods. The cytoplasm appears to be a collection of aggregates formed by the interaction of specific surface configurations—a jigsaw puzzle that solves itself by thermal agitation.

The problem of cellular evolution involves not only the evolution of catalytic specificities (enzymes) but of structure-forming specificities as well. Nature appears to have lavished most of her interest and originality on the latter, since most organisms use very nearly the same fundamental enzyme systems but possess wide structural variations throughout the approximately two million species of animals on the surface of the earth. Since the formation of cell structure, as presented here, involves the formation of numerous complementary molecules, it is interesting that antibody formation, far from being a unique activity, may be merely an adaptation of one of the cell's most characteristic functions.

Many different possibilities arise from the finding of Najjar and Fisher (1956) that not only antigen-specific antibodies may exist, but also antibodies specific for the antibody complex, and further antibodies may exist against this secondary complex, others against the tertiary complex, and so on. In theory, the antigen and the antibodies specific for the secondary and all higher complexes could exist together in solution. Only when the original antigen-specific antibody was added would the complex series of reactions leading to the formation of a definite structure take place. The addition of one molecular species could therefore cause a number of other types to condense with it.

Another point of interest in connection with the formation of structure by specific macromolecular interactants is the effect of an imbalance of interactants. If an "antigen" is present in excess, for example, not only will the antigen fail to precipitate (except in certain horse antisera), but the precipitate (structure) already formed will go into solution.

If a structure is in equilibrium with its dissolved constituents, it is evident that a *small change in the dissolved material or the appearance of new substances that aggregate with it can bring about the dissolution of the original structure*. This appears to be true of the assembly of the entire mitotic system. The soluble, structure-forming molecules are drained off to form a new structure. As a result, part of the previous structure is dissolved. A second solution to the jigsaw puzzle may exist either where several new pieces are added or when a small change is made of the pieces. One solution of the puzzle may be the resting cell, the other the dividing cell.

The interrelationship of structures such as the mitochondria and the cell cortex and the mitotic apparatus has been stressed. The dissolved phases of all of these are probably in equilibrium with their synthetic sites, which are thought to be on the microsomes. The microsomes appear to be much less labile than other cytoplasmic structures and are relatively more stable in solution. They may be considered to have a lability of a different order from that of other cytoplasmic constituents and may be in a very slowly formed equilibrium with the genetic mechanism of the nucleus. We might be tempted to consider the latter as having a lability (or conversely, stability) of still a third order whose gradual approach to equilibrium with the rest of the cell sets a time limit on its life span and inevitably results in degenerative changes (aging) unless reorganization with intercomparison of code systems (as discussed in Anderson, 1956), and the elimination of defects together with restoration of losses can be carried out, as it may be during cell division.

In some instances where the approach to equilibrium is too slow, the process may be accelerated enzymically.

THE FORMATION OF THE ASTERS

In the present view the formation of the astral ray system as a result of the release of a substance produced by the centers is postulated. This substance is thought to be either a polycation or to produce a change similar in effect to that of a polycation. The cytoplasmic changes observed are here interpreted in terms of the gradual production of organized fibrils by the interlinking of soluble proteins or protein clusters.

The reality of astral rays and spindle fibers in the living, dividing cell appears to have been firmly established (Inoué and Dan, 1951; Inoué, 1951; Schrader, 1953; Mazia, 1956). Besides protein, they contain RNA (Pollister and Ris, 1947; Stich, 1951b) and polysaccharide (Monné and Slautterback, 1950; Stich, 1951a). The central role of the mitotic center in the formation of the asters has been postulated almost since their discovery. However, little has been said about how they are

produced. As shown in the previous discussion on the formation of protein fibrils, the release of basic substances or of substrates that alter the change ratios on the cytoplasmic proteins in favor of polycations could initiate a formation of fibrils. The radiating configuration of fibrils is easily explained on the basis of a point source of the factor shifting the charge ratios and on the basis of the theory of Rees (1951). As the first fibril elements are formed in the neighborhood of the centers, they are no longer able to have a free sphere of rotation when a certain average length has been reached. As more of the cytoplasmic and centriole fibril-forming constituents diffuse into this area, the concentration of fibrils continues to increase. The problem of fibril packing is solved as in a tactoid by quasiparallel orientation. Since the aggregate surrounds the centers, the preferred lines of organization would be radial rather than tangential. The diffusion of more polycation or polycation producer from the centers would produce further linear condensation on the distal ends of the radially oriented fibrils, continuing until the astral rays are fully formed. Condensation is not considered as being always in terms of one monomer (protein molecule) condensing on the end of a beaded chain. Rather, a large number of dimers, trimers, and so on, would first be formed. The aggregation of these into long chains would occur in the manner suggested by Rees, since the principles apply equally well to the linking of short chains.

The formation of aster-like structures in solution has been beautifully demonstrated by Waugh (1946). In acid solution, insulin forms highly asymmetric fibrils. These aggregate in solution under certain conditions to form spherites in which the fibrils are *radially oriented*. The rate of formation of these spherites could be changed by varying the protein concentration. It was demonstrated that fibril formation in solution *precèdes* the formation of spherites. The appearance of the latter was favored by a high concentration of *short fibrils*. No spherites were formed under those conditions that lead, initially, to low concentrations of *very long* fibrils. Waugh (1941) has suggested that this phenomenon is related to the reversible formation of the spindle and asters in living cells. He suggests that "there is a fundamental similarity between the forces which maintain the directional molecular aggregation in the insulin gel and the forces which maintain many reversible and non-reversible directional aggregates *in vivo*, although the processes by which the aggregations are brought about may be expected to be different."

The gross cytoplasmic viscosity changes observed in such a system would be, first, an increase in over-all viscosity with the formation of low polymers (e.g., dimers, trimers), and then by a general viscosity drop as the chains are organized into astral rays. The reason is simply that the chains in the latter stage are concentrated in a rather small percentage of the cell volume. Experimentally, this is precisely what is observed (Heilbrunn and Wilson, 1948). In the *Chaetopterus* egg, for example, the viscosity rises after early prophase begins. Then there is a sharp drop as the asters and spindle form. Somewhat similar results were reported by Carlson (1946). Mazia (1956) has taken a somewhat different view and considers that gelation and then liquefaction occur throughout the cell as the mitotic apparatus forms. It should be noted that the idea presented here is a restatement in more modern terms of part of the older theory of the "archoplasm" propounded by Boveri.

Material responsible for the changes in cytoplasmic viscosity may be derived in part from the cell cortex, which decreases in viscosity during division (Heilbrunn and Wilson, 1955).

The bonds holding the fibril components together have been stressed as being largely ionic, with the reservation that other forces may also be involved. Molecules held together by ionic forces should tend to be dissociated by high hydrostatic pressure, since H^+ and OH^- occupy a smaller volume when associated with charged groups on a protein than when combined as water. According to LeChatelier's principle, this electrostrictive effect should cause structures such as a spindle formed by aligned globular molecules held together by salt linkages to solate. Experimentally, this has been shown in a large number of cell types (Brown, 1934; Pease, 1941, 1946; Marsland, 1939, 1942, 1951; Marsland and Brown, 1936, 1942; Marsland and Landau, 1954). The spindle and asters solated *reversibly*, the cortical gel decreased in viscosity under pressure, and amoeboid movement ceased.

These effects have been interpreted in terms of the reversible folding and unfolding of protein molecules (Johnson, Eyring, and Polissar, 1954). However, as these authors point out, ". . . we know of no unequivocal evidence that proteins after synthesis ever reversibly unfold, even partially, into a one-dimensional chain or two-dimensional network" (p. 31). The effects of pressure may be explained equally well on the basis of a disaggrega-

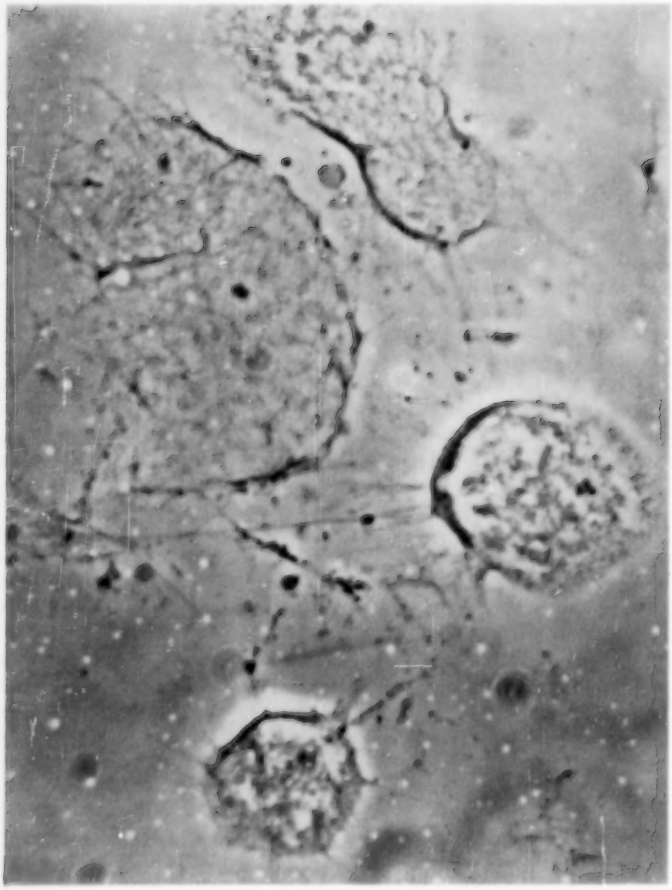

FIG. 3. FIBRIL FORMATION BETWEEN ISOLATED NUCLEI TREATED WITH PROTAMINE SULFATE AT pH 7.1
Nuclei were slightly flattened to allow fibrils that appear to originate from nuclear envelope material to be seen. Note double coiled structures extruding from upper nucleus (Anderson, 1951).

tion of beaded chains as on the basis of the refolding of extended or unfolded protein chains. For reasons previously mentioned, the former view is adopted here.

It should be pointed out that the classical example of specific interaction between large molecules, the antigen-antibody reaction, has been shown in serum albumin to be dependent on the presence of one positively charged group on the antibovine serum albumin antibody and one negatively charged group on the reaction site of the antigen (Singer, 1955). This reaction may, therefore, be considered as being of the general type postulated here. When either of the two ionizing groups was masked, no reaction occurred.

Experimentally, basic dyes or basic proteins added to rat liver breis produced numerous fine, microscopically visible fibrils (Anderson, 1949, 1951). Fig. 3 shows the effect of added protamine sulfate in neutral solution to rat liver nuclei. The chromatin material condenses into fine threads, and the nuclear envelope becomes a series of fine fibrils, many of which are at the limits of resolution of the phase contrast microscope. The substance of the nuclear envelope appears, therefore, to be available for fibril formation and may function in this manner during division.

The actual isolation of the mitotic apparatus by Mazia and Dan (1952) and the partial characterization of the major protein component constitute an important advance in the understanding of the mechanism of cell division. In the sea urchin egg, this apparatus contains about 11.6 per cent of the total protein of the cell (Mazia and Roslansky, 1956). Since calculations showed that the nucleus could contain at the most only about 2 per cent of the material found in the mitotic apparatus, the substance of the apparatus cannot be stored in the nucleus of the cell during interphase. This lends direct support to the concept that the building blocks for the mitotic apparatus—the asters and the spindle—form part of other structures in the resting cell and may also be partly in solution either as single molecules or in the form of soluble complexes. Chèvremont and Fréderic (1951), studying mitosis in muscle cells and fibroblasts from chick embryos and using phase contrast, observed a reduction in size of mitochondria during prophase and metaphase. Certain of the mitochondria were seen to dissolve partially. After mitosis, the mitochondria increased both in size and number. Agrell (1955) observed a sharp drop in the number of mitochondria after the breakdown of the nuclear envelope. Actual counts showed that the mitochondria were dissolved from prophase to metaphase, with a consistent increase in number from metaphase up to the next prophase.

THE SPINDLE

The spindle is here considered to be produced by linear aggregates of structural proteins held together by predominantly ionic forces. The changes in surface properties of these substances necessary to produce linear arrays are thought to be caused by the presence of a polycation or substances capable of producing charge reversal on a part of the surface of the molecule. Possible mechanisms for movement in such systems will be discussed.

The first problem concerns the forces or structures that allow the spindle to exist as a distinct entity. The simplest mechanism would be that of an enclosing membrane, impermeable to the substance of the spindle. The persistence of the nuclear envelope during division has been suggested in the *Tradescantia* stamen hair cells (Wada, 1950). However, certain obvious difficulties arise if such a membrane is to be impermeable to proteins or other colloids. Chief of these is that it cannot persist as an impermeable barrier in the form of the nuclear membrane from generation to generation (Anderson, 1953a). At best, it would provide a mechanism for keeping the spindle material in position but would not explain how it got there in the first place.

Descriptions of the spindle in terms of a gel structure do little better because they generally do not specify the changes in intermolecular bonding necessary to form a gel. The author is reluctant to accept the concept of the spindle as a simple liquid crystal, in view of the multiplicity of compounds known to make up this structure, predominantly proteins, which according to Pfeiffer (1954) include those of the histone or basic type, and RNA and polysaccharide (Monné and Slauterback, 1950; Pollister and Ris, 1947; Stich, 1951b). Adenosine triphosphatase has also been demonstrated on the spindle (Biesele, 1949).

The most plausible description appears to be based on the concept of a separation of colloid phases (Wada, 1955). If this is true, then many of the same molecular species should be found in the interastral ray cytoplasm, in the asters, and in the spindle, but in different proportions. The finding by Mazia and Dan (1952) that the mitotic apparatus consists mostly of a single substance provides strong support for this idea. The test is, of course, the isolation of the same substance for the cytoplasm outside the mitotic apparatus.

The mechanisms described in a previous section as producing the astral rays may serve equally well for the spindle. Such anisodiametric micelles or microfibrils as do not form part of the astral system, either for reasons of length or microcharge distribution, would, if present in sufficient concentration, give rise to ordering of the type described by Oster (1950) as occurring in virus suspensions. The longer fibrils may be found in the spindle since, as was shown by Waugh (1946) with insulin, only the short fibrils tend to form spherites.

If the quasiparallel ordering of the fibrils is due to interaction between fibrils, as was shown with tobacco mosaic virus (Oster, 1950), then the "tactoid" would be expected to fall to the bottom, like virus tactoids. The confinement of these fibrils to the spindle region may be controlled by the presence of a few fibers extending from pole to pole. Free fibrils in the immediate neighborhood of these would tend to be ordered in the same way that particles approaching the edge of a tactoid are ordered. As ordering occurs around a fiber, the concentration of random fibrils in the immediate vicinity is decreased, and other fibrils would tend

to diffuse in. This would continue until the concentration of fibrils in the cytoplasm is lowered to the point where each has approximately a free sphere of rotation. The formation of the original fibers is thought to be caused by the diffusion of polycationic substances from the poles and the kinetochores. The idea that such a substance exists is not new. For example, Wada (1950, 1955), on the basis of cytological studies, has suggested that a secretion from the kinetochore serves to hold or cement the particles of the chromosomal fibers together. If both the kinetochore and the centers elaborate the charge-shifting substances, the formation of fibrils connecting the two is not difficult to explain.

The fundamental mechanism, an association of macromolecules because of changes in the surface charges, would appear to be subject to experimental alteration by both chemical and physical agents. If the masking of acidic groups on the surface of proteins by polycations so as to produce a reversal of charge or the interlinking of such proteins by polycations is essential for spindle formation, then substances capable of interfering with these changes should have profound effects. Specifically, the interfering substance should (1) bear a negative charge, (2) be a fairly large molecule, and (3) bear groups that contribute to its water solubility without markedly altering its charge. Such a substance would be able to occupy sites that would normally bind polycations and effectively prevent the formation of complex structures such as the spindle. The polycation binding area would then be essentially uncharged. As shown in fig. 4, the best spindle poisons, colchicine and N-methyl colchicamide fulfill these requirements. No activity is observed in the absence of the basic group (Lettré, 1952). Another series of active compounds has been built around α,β-diphenylethylamine (stilbylamine), which also contains a basic group. This compound is not active in itself, but addition of various side-chains produces activity. The 4′-ethoxy derivative is the most active of the series.

The specificity of these spindle poisons suggests that the spindle aggregates may be formed through the mechanism described but that specific complementary surfaces are also involved. Colchicine may be specific by virtue of a stereochemical configuration that is more specific for one of the surfaces of the spindle-forming protein than for the components of the chromosome. The net result of the action of colchicine would be that fewer constituents would be available for forming the spindle (i.e., the spindle would be smaller), and polycationic material otherwise used in spindle construction would be free to condense other systems. This would explain why colchicine causes over condensation of the chromosomes (Coleman, 1947; Suomalainen, 1954) in addition to its better-known effects on the spindle. This suggests again that cell division in its entirety may be derived essentially from one basic mechanism.

The spindle is reversibly solated by high hydrostatic pressure. As noted by Pease (1946), the spindle may re-form after pressure solation first around the centers and the kinetochores. This observation again suggests that these organelles serve as centers for organizing spindle miceles.

One of the most formidable difficulties that confronts us when we attempt to treat mitotic mechanisms arises from impressions gained from observing time-lapse motion pictures. The chromosomes on the metaphase plate dance about in an irregular manner and then suddenly move to the poles. The seemingly autonomous movements are

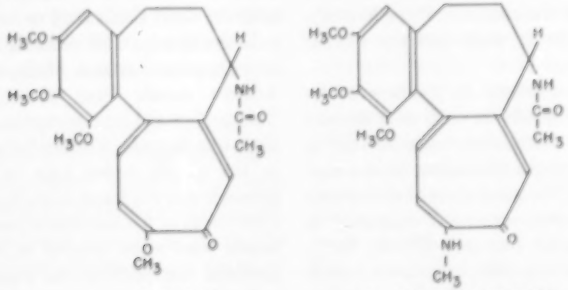

FIG. 4. COLCHICINE (formula of Dewar, 1945) AND N-METHYL COLCHICAMIDE
The latter is four times as active as colchicine.

most puzzling. Similar anomalous behavior has been described by Seifriz (1953). Granules in the streaming protoplasm of plant cells were observed to reverse direction occasionally and move against the stream. Again, parts of the cell appeared to exhibit autonomous behavior.

Much has been said about the extension and contraction of thread-like particles. These do *not* behave like flexible steel rules—either straight or neatly coiled up. Rather, the same molecular agitations that give rise to the now commonplace Brownian movement would be seen to produce similar effects on molecular chains if we could observe small enough segments. A bundle of molecular strands would then appear more like a group of freshly caught eels. Still more violent thrashing about may be expected when the concentration of the contraction-producing substance (ATP?) approaches its critical concentration. Even before it is reached throughout the whole system, the critical value will be exceeded locally in certain segments of the contractile system because of purely statistical fluctuations. Convulsive movements caused by a combination of thermal agitation and localized contractions (which are also ultimately caused by thermal agitation) would be expected to occur. If the chromosomes are attached to such strands, the observed irregular movements should be expected.

Part of the difficulty is that no model of such a system is available, whereas ordinary Brownian movement is easily demonstrated in inanimate particles. The attempt to make a suitable model with very dilute nucleoprotein gels containing visible particles did yield interesting results, however. When the preparation was forced through a capillary tube on a microscope stage, we observed irregular flow, first down the center, then along the edge, and not infrequently in two directions at once! Occasionally a particle would move with the stream, stop, and then reverse direction. The observations are a demonstration of the elastic properties of a relatively few molecules. They illustrate that an anomalous movement of cell structures may find an explanation in the properties of long-chain contractile molecules whose properties are rarely observed outside the cell at the microscopic level. The molecules or molecular strands need not be attached to visible structures at both ends. The movement of a particle by a strand may occur when the other end of the strand is attached to a weak "gel island" that may serve as an effective "sea anchor."

The picture of the spindle that emerges is one of a few long fibrils formed by interlinking protein molecules with polycationic materials produced by the mitotic centers and the kinetochores. These orient fibrillar material occurring in the cytoplasm and produce tactoid areas between the fibrils. (The word "tactoid" is used in the descriptive sense and does not imply the presence of long-range forces.) Such a structure would have the extreme lability characteristic of spindles in living cells, viz., sensitivity to hydrostatic pressure and chemical agents and to agitation with a microneedle. Although disulfide bonds might be important in producing the fibrils that become oriented around the fibers, the lability of the spindle indicates that these bonds are not involved in maintaining the structure as a whole.

THE BREAKDOWN OF THE NUCLEAR ENVELOPE

Very little experimental information is available on the mechanism of the breakdown or dissolution of the nuclear envelope during cell division or in regard to its reformation at the end of division. It has been proposed by Heilbrunn and Wilbur (1937) and more recently by Goldstein (1952) that calcium, released from the cortex of *Nereis* or *Chaetopterus* eggs, activates a proteolytic enzyme of a type described by Gross (1952). Nuclear envelopes of isolated rat liver nuclei are indeed easily digested by proteolytic enzymes (Anderson, 1953a and b), but such enzymes have even more drastic effect on nucleoproteins.

Observations by Monné (1946) and by Baud (1948) suggest the possibility that surface-active substances may be involved. From studies on the stability of nuclei in breis, I prefer to conclude that the structural component of the envelope is not digested in the usual sense, but becomes part of the mitotic apparatus, returning to its former position at the nuclear-cytoplasmic interface at the end of division. In this connection, Schrader (1953) has stressed the probable role of envelope material in mitotic events.

A simple explanation for the dissolution of the nuclear envelope is to be found in precisely those changes that may result in the dissolution of parf of the mitochondrial system. If the substance ot this structure is in equilibrium with its dissolved constituents, then a migration of the latter into the structure of the mitotic apparatus should result in a gradual dissolving of the envelope. Furthermore, if the substance causing the dissolved molecules to link together at dimers and trimers origi-

nated in the nucleus, the disappearance of the nuclear membrane would be expected to be a very early event, which indeed it generally is.

CHROMOSOMAL MOVEMENTS

Chromosomal movements have been reviewed in detail by Schrader (1953). This discussion will be largely limited to a consideration of molecular changes that could account for the movements observed.

Energy is required to keep fibrils such as those that compose spindle fibers and astral rays in an extended condition. In muscle, the extending force is thought by many to be an electrostatic one. Contraction occurs when the electrostatic forces are diminished and allow an "entropic" contraction to occur. The muscle fibrils could be positively charged in the extended state and be discharged by the highly anionic ATP molecule. Whether binding and contraction go together or the splitting of ATP is crucial to the contraction process cannot be decided as yet. Considerable evidence supports the conclusion that the spindle fibers do respond to ATP (Weber, 1955).

The formation of astral and spindle fibrils has been postulated here as being caused by substances that alter the surface charge on the normally negative or anionic cellular proteins, so as to make them at least partially cationic. The result could well be a beaded chain system which is held in an extended state by positive charges, and similar to that proposed by Morales, Botts, Blum, and Hill (1955). Contraction of such a system should occur when the surface charges are neutralized by adsorption of ATP or some similar substance.

The source of the substance producing the positive electrostatic charge on the fibrils has been postulated as being in the centers and the kinetochores. It is interesting that, whereas calcium and magnesium have been implicated in charge reversal in muscle proteins, the organic bases such as spermine, which are widely distributed and which could also serve as a ready and controllable source of positive charges, have been largely overlooked. Fujii's report (1954) that zinc moves from the nucleolus to the spindle during division is of interest, since several organic bases react with the reagent used.

If the contractile model proposed by Flory (1957) is adopted, then the spindle may be considered to be partially crystalline and to be stabilized by the forces holding crystalline segments together. The release of any charged substance such as ATP would, when adsorbed on the fibrils, disrupt the crystalline segments and result in contraction as the fibrils return to an amorphous state. The crystallization could also help to account for the movement of the chromosomes to the spindle plate.

If the fiber-forming substances are produced at the centers and the kinetochores, why are not the kinetochores of sister chromosomes merely bound tightly together? Why should they instead be pulled apart? The answer may indeed be that a considerable amount of fiber-forming material is condensed between them. If this material were somewhat over-condensed (contracted), it might indeed revert to an extended shape at some later time, and thereby cause such an expansion of the spindle area between the chromosomes as occurs in many cells. An alternative, and not necessarily counter-possibility, may lie in the effect of RNA that the chromosomes shed between them (Jacobson and Webb, 1952; Ris and Kleinfeld, 1952). Since RNA is a polyanion, it would have a solating effect on at least part of the spindle between the separating chromosomes. This solated material is in admirable position to diffuse to the cell cortex and creat a band of extra cortical material at the edge of the space occupied by the metaphase plate. Here it is not necessary to postulate a mechanism for reforming this material into a contracting gel-work, since calcium from the surrounding medium could serve to cross-link it and keep it in a constant state of tension.

It may be asked how the mitotic system forms, remains in a state of quasi-stability for a considerable time (metaphase), and then in a very short period goes through anaphase and into telophase. As we know, from observing time-lapse motion pictures of dividing cells, the chromosomes at the metaphase plate move and jostle about. The state of the chromosome fibers at this point may be similar to that described in a theoretical model of a myosin system contraction by adsorbing ATP (Morales et al., 1955). Here very little change occurs as ATP is adsorbed, until a critical point is reached where almost maximal contraction occurs. Addition of more ATP causes little further change. In the metaphase cell, the adsorption and breakdown of ATP on the chromosomal fiber would proceed at a rate dependent on the rate of ATP synthesis maintained by the cell. If no special additional ATP synthesis occurs during division, as appears to be the case experimentally, much time might elapse before the critical concentration is reached on the fibers. All fibers could be very

close to this concentration at the *same* time. Production of ATP by the kinetochore in rather small amounts could produce contraction near the chromosomes. Alternatively, additional polycations produced by the kinetochores might be necessary to produce fibrils that can contract. The metaphase pause and the rapid anaphase movement do not necessarily require a sudden burst of synthetic activity or a special signaling substance or stimulus.

A similarity between the kinetochore and the mitotic center has been suggested on theoretical (Darlington, 1936; Schrader, 1936) and structural grounds (Schrader, 1936). It was pointed out that they possess similar staining reactions and similar functions during mitosis. In meiosis in atypical spermatogenesis in viviparid molluscs, Pollister (1939) found that kinetochores' detached from degenerating chromosomes, became associated with the centriole and mimicked its behavior and appearance accurately. If this similarity holds true biochemically, it may be postulated that both function by producing low-molecular-weight polycations. The movements of the centrioles during spermatogenesis and their close association with the nucleus during its period of condensation suggest that the centrioles may function here to produce the basic subprotein protamine, which, as discussed by Anderson (1956), may serve both for efficient DNA packing and as the cause of sperm aster formation in the fertilized egg. The centrioles are also associated with the formation of fibrils incorporated in the sperm tail. The structural agent proposed by Swann (1951a,b, 1952a,b, 1954) may be either additional polycationic material or ATP. In connection with the assumption that a substance is produced at a site because a physical effect is observed at increasing distances, it is evident that the site may just as well be a destructive center (a "sink"), and that the effect seen may be due to a decrease instead of an increase in the concentration of an agent.

CYTOKINESIS

As stressed by Mazia (1956), the mechanisms by which the cell body divides vary so markedly between plant cells, egg cells, and cells of irregular shape that it is difficult to detect any basic unity; in fact, little may exist. Studies in which hydrostatic pressure was used support the contracting ring theory (Lewis, 1951; Marsland, 1951), which assumes that cleavage occurs as a result of the contraction of an equatorial ring in the furrow, a concept supported by work with cell models (Hoffmann-Berling, 1954b,c, 1955). Mitchison and Swann (Mitchison, 1952; Mitchison and Swann, 1954a,b; Roberts, 1955) have presented evidence for an expanding membrane, produced by the release of a "structural agent," that pushes inward at the equator and causes division. Dan (1948) believes the driving force to be the elongation of the spindle, which, by pushing the asters apart, causes a constriction to appear in the cleavage plane. It is not unlikely that all three mechanisms actually occur, and no decision in favor of any one theory can be made on the basis of the considerations presented here.

However, certain relations between these mechanisms and the general scheme presented here deserve comment. The contracting ring theory has been discussed in a preceding section in which it was proposed that material solated in the presence of RNA shed by the chromosomes diffused to the cortex. If all cortical material is maintained in a state of contraction, then constriction should occur where an excess is present. The elongation of the spindle, necessary in the theory of Dan, could be produced by subtile changes in the packing of the spindle fibrils, due to changes in the average fibril length or in surface charge. The expanding membrane evident in the work of Mitchison and Swann would require an increased tendency for soluble cell constituents to form such membranes. It is of considerable interest that several basic substances, including the basic dye Victoria blue, tend to cause bleb formation (an increase in surface area) in living cells (Lettré, 1951). These mechanisms may therefore ultimately depend on the one proposed here.

THE RECONSTRUCTION OF THE RESTING CELL

Cell division has been considered here as being set in motion by the release of a polycationic material that, adsorbed on cellular colloids, could alter the ratio of positive and negative charges, or by the production of a substance capable of producing an equivalent effect, as discussed in a previous section. The problem of telophase is to return the cell to its original state.

If the mitotic apparatus is in equilibrium with soluble constituents, which are also in equilibrium with the formed elements including the cell cortex, the mitochondria, and the nuclear envelope, then an increase in those molecular species that are characteristic of the latter structures but do not participate in the formation of the mitotic appa-

ratus should shift the balance at least partially back in favor of the resting state.

The synthesis of substances competing with the mitotic apparatus for structural proteins requires that material stimulating the production of protein in the cytoplasm be released from the nuclear apparatus at precisely the right moment. Since a variety of lines of evidence now favor the idea that such a substance would most likely be a nucleoprotein particle (Borsook et al., 1950; Hultin, 1950; Keller, 1951; Allfrey, Daly, and Mirsky 1953), this role may be assigned to the RNA shed by the chromosomes as they leave the equatorial plate. The movement of the chromosomes to the poles should allow enough time for the RNA to become incorporated into a protein-synthesizing particle and for protein synthesis to

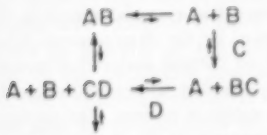

FIG. 5. FORMATION OF STRUCTURE AND OF FIBRILS BY ALTERNATE PRODUCTION OF POLYCATION C AND POLYANION D

The cell structure, AB, is in equilibrium with dissolved A and B. On the addition of C, the dimer unit BC is formed, which polymerizes to form fibrils. Addition of D, which competes for C, results in the formation of the strongly bound complex CD, which essentially removes C from the system. A and B are then free to re-form cell structure AB. A similar system may exist where A is absent and structure is formed by the cross-linking of B, as shown in Fig. 6.

start. Since the dissolution of the apparatus between the poles would then occur first, structural elements sufficient to form increasing amounts of cortex should be available in the plane perpendicular to the spindle axis. This material could form a constricting band that would pinch off the cell.

In the simplest case, the formation of a cell structure may be considered as being caused by the formation of a complex between two molecular species, A and B, which are in equilibirum with a solution containing the same molecules. If a second structure can be formed from B and C, then the following can be expected:

$$AB + C \rightleftarrows A + B + C \rightleftarrows BC + A.$$

If we assume that the over-all equilibrium is shifted to the right, then the addition of C to the mixture of A and B should result in the dissociation of part of AB and the formation of BC. To reverse this reaction, the further addition of a molecule that will compete with B for C will result in the re-formation of AB. The complete scheme is shown in Fig. 5. CD is considered to be more stable than AB or BC. If AB is the interphase structure, BC would be the division structure. The entire cycle may proceed, in a system where all constituents are constantly being synthesized and destroyed, when the synthetic rates of all reactants (A, B, C, and D) vary appropriately.

In this discussion C may be considered to be a polycationic material, and the role of D could be filled by an acid polysaccharide. Experimentally, acid polysaccharides such as heparin will cause rapid swelling of nuclear gels (Anderson and Wilbur, 1951; Roberts and Anderson, 1951), solation of amoeba cytoplasm, and the disaggregation of microsomes (Hoster et al., 1950), thus demonstrating its ability to alter cell structures. A cyclical variation in polycation and polyanion concentration could therefore underlie the whole division mechanism.

Such macromolecular displacements probably play a very important role in cell function. For example, acid polysaccharides could well displace finished protein molecules from synthetic sites. Mucus, which is so widely and easily produced, may well be synthesized in such a process. The protein moiety would be synthesized on a template, whereas the acid polysaccharide may be formed in solution. The polysaccharide would compete with the template for the protein molecule and combine with it to complete the synthesis. In an analogous manner, D could displace C off BC and effectively remove it from the reaction.

The mechanism for reversibly forming fibrils from molecules that also form three-dimensional structures in the cell is shown in Fig. 6. The formation of membrane-like structure is shown as being caused by interaction of oppositely charged areas on the same molecule. The structure is in equilibrium with free molecules that may be also solubilized by complex formation with other molecules indicated for convenience in Fig. 6 as being smaller than the structure-forming molecules. In the presence of polycationic molecules (shown as oblong bodies), the structure-forming molecules are condensed into chains. Schematic drawings of the same structures are shown on the right in Fig. 6.

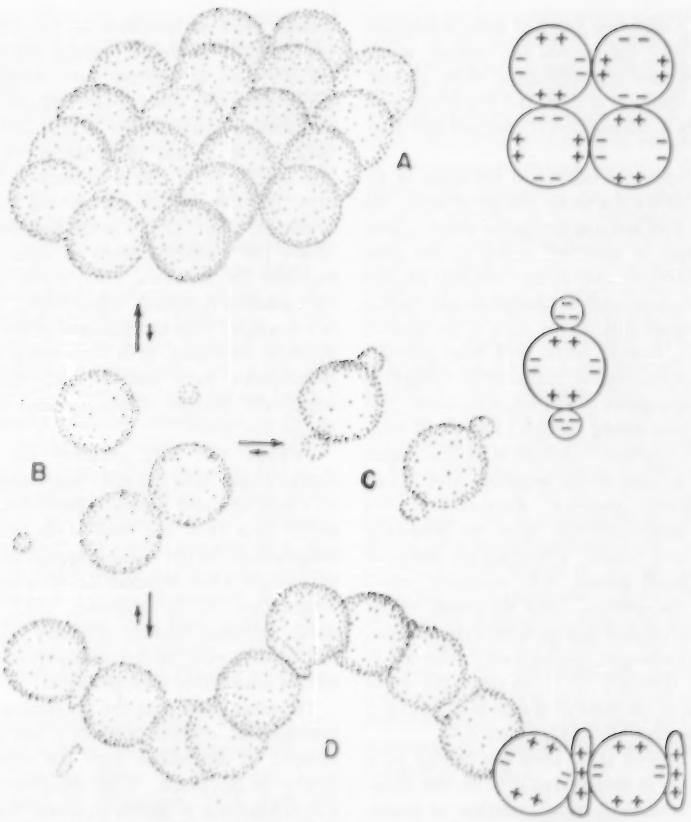

FIG. 6. FORMATION OF TWO TYPES OF STRUCTURE BY STRUCTURE-FORMING PROTEINS

In A, protein condenses to form a sheet that is in equilibrium with protein in solution (B) and with solubilized protein molecules (C). Addition of a polycation (shown as an oblong molecule) results in fibril formation (D). The solubilizing molecules at C are shown, for convenience, as small spheres. The distribution of charges is shown schematically along the right margin.

THE CHARGE OF CYTOPLASMIC COLLOIDS

As has been pointed out (Anderson, 1956), the sign of the predominant charge on cell colloids is fundamental to considerations of the nature of gelation in cells generally and to the primitive cell division mechanism here proposed specifically. This mechanism depends on the production of positively charged groups on otherwise negatively charged particles, causing either condensation or fibril formation. Since there has been considerable disagreement as to whether the predominant charge on cytoplasmic colloids is negative or positive, a somewhat detailed discussion of the subject is necessary. The term "cytoplasmic colloids" includes a variety of colloidal particles and is not properly a generic entity.

Heilbrunn (1928; Heilbrunn and Daugherty, 1939) has summarized the evidence for a predominant positive charge, whereas Chambers and Kao (1952) have presented some of the data supporting the concept that the charge is predominantly negative. The former concept received support initially from elemental analyses of whole *Arbacia* eggs, which demonstrated a high ratio of divalent to monovalent cations. These results are somewhat misleading since the jelly coat contains acid polysaccharides that may be expected to bind calcium as does also the nucleus (Williamson and Gulick, 1942). If the presumed positive charge on cell col-

loids is due to adsorbed calcium ions, substances that bind calcium; e.g., citrate and versene, would be expected to have a precipitating effect. Experimentally, the opposite is true, and the injection of calcium results in coagulation (Chambers and Kao, 1952).

Since the amount of calcium is too small to account for a positive charge by charge reversal, one is at a loss to find suitable groups to which a positive charge may be ascribed. Actually, the great majority of inorganic cations are monovalent, and the inorganic anions such as phosphate and sulfate exist for the most part in the form of polyanions such as ATP, nucleic acids, and acid polysaccharides. No polycation of comparable strength is found in the cytoplasm of the interphase cell. The only organic base strong enough to be at all comparable with phosphate or sulfate is choline, which is not known to exist as the recurring base in any basic cytoplasmic polymer. Furthermore, the majority of tissue proteins have an isoelectric point in the acid region, indicating an excess of available carboxyl groups over available amino groups in neutral solution. Since the charge on the colloidal constituents *is* negative, the typical mammalian cell, for example, contains very little monovalent anion (HCO_3^-, Cl^-), whereas the great preponderance of the cationic charge is monovalent (K^+, Na^+) (see Gamble, 1952, Chart 2-A).

It may be argued that, since the charge on a colloidal particle is determined only by the properties of its surface, a small number of multicationic molecules coating these particles might result in an over-all positive charge excess in spite of the evidence to the contrary already cited. Experimental studies on the surface properties of isolated rat liver mitochondria suggest that some RNA may be located on the surface (Schneider, 1946; Anderson and Wilbur, 1950). Addition of a polycation such as protamine flocculates brei constituents (Weil et al., 1952), as does the basic dye Janus green B (Anderson, 1949). It is difficult to escape the conclusion that the predominant charge is negative.

A similar conclusion may be drawn from the observation of cells broken in various solutions (Heilbrunn, 1928, 1952; Costello, 1933). Citrate, a trivalent anion, *prevents* gelation or flocculation of the extruding cytoplasm, whereas calcium (which in low concentration would be expected to cross-link and precipitate a solution of anionic colloids) produces the familiar surface precipitation reaction. Furthermore, as is well known, anionic colloids tend to flocculate as the pH is lowered toward their isoelectric points, whereas cationic colloids tend to become more soluble. The viscosity-*increasing* effect of lowering cell pH has been repeatedly demonstrated (Loeb and Blanchard, 1922; M. R. Lewis, 1923; Barth, 1929; Minshall and Scarth, 1952) and is consistent with the concept that the colloids are moving closer to their isoelectric point; i.e., they are negatively charged. Above pH 7 solation tends to occur as would be expected (M. R. Lewis, 1923; Barth, 1929). Under very alkaline condition, where highly viscous DNA is dissociated from the proteins of the nucleus, the viscosity increases. It is interesting that nuclear constituents have usually been thought to be negatively charged (Churney and Klein, 1937; Heilbrunn, 1952).

Perhaps the best evidence on cytoplasmic charge comes from the early microinjection studies of Chambers and others (Chambers, 1924), who found that only the basic dyes caused a local coagulation. No pH changes appear to be involved. Protamine, when injected, causes a similar sudden coagulation (N. G. Anderson, 1952, unpublished data), whereas heparin produces liquifaction. If the colloids were positively charged, the opposite results would have been produced.

The assumption that the predominant charge on protoplasmic colloids is positive has introduced a number of difficulties into the colloid-chemical theory of Heilbrunn. Thus immersion of cells in $CaCl_2$ solutions is shown to cause first a solation and then a gelation. The solation is presumed to be due to the effect of adding divalent cations to a polycationic system, although Heilbrunn later noted that the problem of determining the effect of various cations on the internal protoplasm of cells is rather complicated since in cells immersed in solutions of sodium or potassium salts, the sodium or potassium ions may release calcium from the outer cortical protoplasm (Heilbrunn, 1952, page 97). However, in invoking the participation of calcium in stimulation and other cellular responses, Heilbrunn states, "Typically, when calcium in small amounts is released to the interior of a cell, a gelation occurs . . ." In the surface precipitation reaction, calcium is shown to cause a precipitation of cytoplasmic constituents. Clearly, calcium should promote the outflow of the cytoplasm if it is positively charged. Since the actual findings are in such marked opposition to the original assumption, the dilemma was solved by postulating the existence of a process similar to

blood clotting. This was done by assuming that here calcium plays a role, not in the stabilization or destabilization of colloids, but in activating thromboplastic substances. The roles of citrate and oxalate, which sould have profound effects on a polycationic system (especially one whose charge is due to adsorbed calcium), are attributed to their effects on a clotting mechanism. Heparin, the physiological polyanion *par excellence*, which again should wreak havoc in a polycationic system, prevents cytoplasmic gelation. Again, the effect is ascribed to a clotting mechanism similar to that found in vertebrate blood (Heilbrunn, 1952). Lastly, in breis, calcium is not released by a variety of experimental procedures, but is actually taken up as would be expected in a system bearing a predominantly negative charge. In order to demonstrate calcium "release" as the colloid-chemical theory would predict, one must add more calcium and consider a diminished binding of the added calcium as "calcium release" (Weimar, 1953). As is evident, the anomalous aspects of this theory largely disappear if one assumes instead that the predominant charge is negative. The electrophoretic studies that have been cited as conclusive (Heilbrunn and Daugherty, 1939) have not been successfully repeated (Tobias and Solomon, 1950).

The data indicating that calcium decreases and potassium and sodium increase cytoplasmic viscosity, with *opposite* effects on the cortex, have been summarized by Heilbrunn (1952, page 96) and deserve comment here. The precipitation of negatively charged colloids by cations of higher valence, prompted him to interpret these findings as indicating that the dispersed particles of the protoplasmic colloids bear a positive charge. (Certain qualifying statements are added to the effect that this is true only when the ions enter slowly since gelation occurs when free calcium enters rapidly.) The experimental observations are reinterpreted here on the assumption that: (1) the cell cortex is largely composed of a calcium complex, (2) the constituents of the cortex complex (protein, acid polysaccharide, etc.) are normal constituents of the cytoplasm, (3) an equilibrium exists between these substances in the cortex and in the cytoplasm, and (4) the complex-forming substances in the cytoplasm are generally in the form of their potassium or sodium salts. The first assumption is borne out by a number of experiments cited by Heilbrunn. The second assumption is borne out by the many observations of the formation of a surface precipitation in outflowing protoplasm in the presence of calcium, where the precipitated material is considered to be identical with that of the normal cortex. In a cell existing in a calcium-containing medium (as is generally the case), the cortex is thought to represent only part of the complex-forming material, the rest being distributed throughout the cytoplasm. When the calcium content of the surrounding medium is increased, it penetrates the cell slowly and precipitates *more* of the complex-forming material, decreasing its concentration in the cytoplasm and also the viscosity of the cytoplasm. The cortical viscosity, therefore, increases and that of the cytoplasm decreases as is observed. The result is, therefore, very different from that seen when calcium is injected into the cell, where it precipitates at once all cortex-forming materials.

When an excess of sodium or potassium is added, calcium may be expected to be displaced from the cortex and from the cell much as calcium may be eluted from an ion-exchange resin. The result is a softening and dispersion of the cortex-forming materials throughout the cell, resulting in a large decrease in cortical viscosity and a small increase in the viscosity of the rest of the cytoplasm as is observed. This interpretation, which harmonizes the results obtained with both injection and immersion studies, may bring some respite in the long argument that has resulted from these seemingly conflicting findings.

DISCUSSION

Cell division in its entirety—with the erection of the mitotic machinery, with its precise functioning and subsequent disappearance, and with the reorganization of one cell into two complete daughter cells—would seem to lie in the province of the arts rather than the sciences. The special cases, such as spermatogenesis, oogenesis, and the variations and exceptional instances so treasured and emphasized by the cytologist, appear to far exceed the capabilities of any mere molecular assemblages, to say nothing of the shear impossibility of packing the entire mechanism into tiny cells to produce others in their image, complete, with no missing piece, not once, but through long spans of time.

It would seem logical to assume that the division mechanism, which originated in a single primeval particle and which has had at least the possibility of as much experimentation expended on its development as any other product of evolution, would

be characterized by two things: (1) economy of materials, and (2) economy of methods. This is especially true since the same mechanism appears throughout the whole animal kingdom. Put somewhat more naïvely, if it could be done more simply, sooner or later it ought to be. Operationally, a mechanism drawing materials from those readily available in several cell structures and that is triggered by variations in the rate of synthesis of substances normally present is more amenable to attack than one involving a whole complex of special substances synthesized by other suitably controlled mechanisms, to be destroyed when no longer needed by still other special enzymes. This latter idea, as partially stated, assumes that, " . . . during mitosis there must be a need for special enzymes involved in functions such as dissolving and regenerating the nuclear membrane, and synthesizing and dissolving the special protein of the mitotic apparatus" (Monty et al., 1956). Enzymes to destroy G, H, and I, to synthesize J; enzymes to destroy J and resynthesize G, H, and I; enzymes to destroy the enzymes destroying G, H, and I; templates to make the enzymes at a particular time; mechanisms to inhibit template utilization at other times; a sequential timer that senses when each task is complete and signals the next—such complexity, even if it did exist, should not confront the investigator at the outset. Further, some of the peculiar division patterns often reviewed may be based on erroneous observations, unusual fixation artifacts, or incorrect interpretation of stained figures. These "exceptions" should not be treasured, they should be repeated, using living cells if possible.

In the first two papers of this series, the author attempts to coordinate certain facts about cell division in such a manner as to suggest unifying relations and critical experiments to test the validity of these relations. The need for extensive physical and chemical characterization of as many molecular species as can be isolated from cells becomes self-evident from these considerations. It is in terms of the properties of these that the story of cell division must eventually be rewritten.

Other papers in this series will deal with experimental findings that bear on the material discussed here.

LIST OF LITERATURE

AGRELL, I. 1955. A mitotic rhythm in the appearance of mitochondria during the early cleavages of the sea urchin embryo. *Exp. Cell Res.*, 8: 232–234.

ALLFREY, V., M. M. DALY, and A. E. MIRSKY. 1953. Synthesis of protein in the pancreas. II. The role of ribonucleoprotein in protein synthesis. *J. gen. Physiol.*, 37: 157–175.

ANDERSON, N. G. 1949. Master's Dissertation, Duke University.

——. 1951. Doctor's Dissertation, Duke University.

——. 1953a. On the nuclear envelope. *Science*, 117: 517–521.

——. 1953b. Studies on isolated cell components. VI. The effects of nucleases and proteases on rat liver nuclei. *Exp. Cell Res.*, 5: 361–374.

——. 1956. Cell division. I. The primeval mechanism, the initiation of cell division, and chromosomal condensation. *Quart. Rev. Biol.*, 31: 169–199.

——. 1957. Labile colloidal complexes of the cytoplasm. In *Symposium on Biocolloids, J. cell. comp. Physiol.*, Suppl., in press.

——, and K. M. WILBUR. 1950. Release of nucleic acids from cell components by heparin. *Fed. Proc.*, 9: 254.

——, and ——. 1951. Studies on isolated cell components. II. The release of a nuclear gel by heparin. *J. gen. Physiol.*, 34: 647–656.

ARNESEN, K., Y. GOLDSMITH, and A. D. DULANEY. 1949. Antigenic properties of nuclei segregated from spleens of normal and leukemic mice. *Cancer Res.*, 9: 669–671.

BAHR, G. F., and W. BEERMANN. 1954. The fine structure of the nuclear membrane in the larval salivary gland and midgut of *Chironomus*. *Exp. Cell. Res.*, 6: 519–522.

BARBU, E., and M. JOLY. 1950. Mécanismes de gélification de la sérumalbumine. Étude par la biréfringence d'ecoulement. *Bull. Soc. Chim. biol.*, Paris, 32: 116–122.

——, and ——. 1953. The globular-fibrous protein transformation. *Disc. Faraday Soc.*, No. 13: 77–93.

BARTH, L. G. 1929. The effects of acids and alkalies on the viscosity of protoplasm. *Protoplasma*, 7: 505–534.

BAUD, C. A. 1948. Action de divers composés tensio-actifs sur la texture de la membrane nucléaire. *C. R. Soc. Biol., Paris*, 142: 181–182.

BENSLEY, R. R. 1947. On the nature of the pigment of mitochondria and of submicroscopic particles in the hepatic cell of the guinea pig. *Anat. Rec.*, 98: 609–619.

BERNAL, J. D. 1940. Structural units in cellular physiology. In *The Cell and Protoplasm* (F. R. Moulton, ed.), pp. 199–205. A.A.A.S. Pub. No. 14, Washington, D. C.

——, and I. Fankuchen. 1941. X ray and crystallographic studies of plant virus preparations. I. Introduction and preparation of specimens. II. Modes of aggregation of the virus particles. *J. gen. Physiol.*, 25: 111–146.

Biesele, J. J. 1949. Phosphatases of the mitotic apparatus in cultured normal and malignant mouse cells. In *Proc. First Nat. Cancer Conf., Amer. Cancer Soc. and Nat. Cancer Inst.*, pp. 34–41. Washington, D. C.

Borsook, H., C. L. Deasy, A. J. Haagen-Smit, G. Keighley, and P. H. Lowy. 1950. Metabolism of C^{14}-labeled glycine, L-histidine, L-leucine, and L-lysine. *J. biol. Chem.*, 187: 839–848.

Brachet, J. 1956. Further observations on the action of ribonuclease on living amoeba. *Exp. Cell. Res.*, 10: 255–256.

Bradfield, J. R. G. 1950. The localization of enzymes in cells. *Biol. Rev.*, 25: 113–157.

Brown, D. E. S. 1934. The pressure coefficient of "viscosity" in the eggs of *Arbacia punctulata*. *J. cell. comp. Physiol.*, 5: 335–346.

Carlson, J. G. 1946. Protoplasmic viscosity changes in different regions of the grasshopper neuroblast during mitosis. *Biol. Bull., Woods Hole*, 90: 109–121.

Chambers, R. A. 1924. The physical structure of protoplasm as determined by microdissection and injection. In *General Cytology* (E. V. Cowdry, ed.), pp. 235–309. University of Chicago Press, Chicago.

——, and C. Y. Kao. 1952. The effect of electrolytes on the physical state of the nerve axon of the squid and of *Stentor*, a protozoon. *Exp. Cell Res.*, 3: 564–573.

Chèvremont, M., and J. Frédéric. 1951. Recherches sur le comportement du chondriome pendant la mitose. *C. R. Soc. Biol., Paris*, 145: 1245–1247.

Churney, L., and H. M. Klein. 1937. The electrical charge on nuclear constituents (salivary gland cells of *Sciara coprophila*.) *Biol. Bull., Woods Hole*, 72: 384–388.

Clark, J. A., and G. E. Hair. 1932. Observations on the mitochondria of the hepatic cell of the frog in normal and hyperglycemic state. *Z. Zellforsch.*, 15: 123–130.

Claude, A. 1948. Studies on cells: morphology, chemical constitution, and distribution of biochemical functions. *Harvey Lect.*, 43: 121–164.

——. 1949. Proteins, lipids, and nucleic acids in cell structures and functions. *Advanc. Protein Chem.*, 5: 423–440.

Coleman, L. 1947. Chromosome abnormalities in an individual of *Chorthippus longicornis* (Acrididae) *Genetics*, 32: 435–447.

Cornman, I. 1944. A summary of evidence in favor of the traction fiber in mitosis. *Amer. Nat.*, 78: 410–422.

Costello, D. P. 1933. The surface precipitation reaction in marine eggs. *Protoplasma*, 17: 239–257.

Cowdry, E. V. 1918. The mitochondrial constituents of protoplasm. *Contr. Embryol. Carneg. Instn.*, 8(25): 39–160.

Dallam, R. D. 1955. Studies on the chemical composition of nuclei and cytoplasmic granules. *Arch. Biochem. Biophys.*, 54: 24–37.

Dan, J. C. 1948. On the mechanism of astral cleavage. *Physiol. Zool.*, 21: 191–218.

Darlington, C. D. 1936. The external mechanics of the chromosome. I. The scope of enquiry. *Proc. roy. Soc.*, B, 121: 264–319.

DeDuve, C., and J. Berthet. 1954. The use of differential centrifugation in the study of tissue enzymes. *Int. Rev. Cytol.*, 3: 225–275.

Dewar, M. J. S. 1945. Structure of colchicine. *Nature, Lond.*, 155: 141–142.

Dounce, A. L. 1950. Enzyme systems of isolated cell nuclei. *Ann. N. Y. Acad. Sci.*, 50: 982–997.

——. 1954. The significance of enzyme studies on isolated cell nuclei. *Int. Rev. Cytol.*, 3: 199–223.

Dulaney, A. D., Y. Goldsmith, K. Arnesen, and L. A. Buxton. 1949. A serological study of cytoplasmic fractions from the spleens of normal and leukemic mice. *Cancer Res.*, 9: 217–221.

Farrant, J. L., and E. H. Mercer. 1952. Electron microscopical observations of fibrous insulin. *Biochim. biophys. Acta*, 8: 355–359.

Flory, P. J. 1957. Crystallinity and dimensional changes in fibrous proteins. In *J. cell. comp. Physiol.*, Suppl. (Symposium on Biocolloids), in press.

Foster, J. F., and E. G. Samsa. 1950. Streaming birefringence of denatured ovalbumin. *Science*, 112: 473–474.

——, and ——. 1951a. Streaming orientation studies on denatured proteins. I. Heat denaturation of ovalbumin in acid media. *J. Amer. chem. Soc.*, 73: 3187–3190.

——, and ——. 1951b. Streaming orientation studies on denatured proteins. IV. Denaturation of ovalbumin in the presence of urea. *J. Amer. chem. Soc.*, 73: 5388–5391.

Frey-Wyssling, A. 1953. *Submicroscopic Morphology of Protoplasm*. Elsevier Press, Houston.

Fujii, T. 1954. Presence of zinc in nucleoli and its possible role in mitosis. *Nature, Lond.*, 174: 1108–1109.

Gamble, J. L. 1952. *Chemical Anatomy, Physiology, and Pathology of Extracellular Fluid* (5th ed.). Harvard University Press, Cambridge.

Goldstein, L. 1952. The mechanism of nuclear breakdown in the Chaetopterus egg. *Biol. Bull., Woods Hole*, 103: 292.

GREENFIELD, R. E., and V. E. PRICE. 1956. Liver catalase. III. Isolation of catalase from mitochondrial fractions of polyvinylpyrrolidone-sucrose homogenates. *J. biol. Chem.*, 220: 607–618.

GROSS, P. R. 1952. A study of colloidal changes in sea urchin egg homogenates. *Biol. Bull., Woods Hole*, 103: 293.

GUILLERMOND, A. 1934. Les constituants morphologiques du cytoplasme: le chondriome. In *Actualités Scientifiques et Industrielles, No. 170*. Hermann & Cie., Paris.

GUTHRIE, M. J. 1925. Cytoplasmic inclusions in cross-activated eggs of teleosts. *Z. Zellforsch.*, 2: 347–381.

HALE, A. J., and E. R. M. KAY. 1956. A comparison of nuclear dry weights determined by chemical and by interferometric methods. *J. biochem. biophys. Cytol.*, 2: 147–158.

HEILBRUNN, L. V. 1928. The colloid chemistry of protoplasm. *Protoplasm—Monogr., Berl., Vol. 1*. Borntraeger, Berlin.

——. 1952. *An Outline of General Physiology*, 3rd Ed. W. B. Saunders Company, Philadelphia.

——, and K. DAUGHERTY. 1939. The electric charge of protoplasmic colloids. *Physiol. Zool.*, 12: 1–12.

——, and K. M. WILBUR. 1937. Stimulation and nuclear breakdown in the *Nereis* egg. *Biol. Bull., Woods Hole*, 73: 557–564.

——, and W. L. WILSON. 1948. Protoplasmic viscosity changes during mitosis in the egg of *Chaetopterus*. *Biol. Bull., Woods Hole*, 95: 57–68.

——, and ——. 1955. The initiation of cell division in the *Chaetopterus* egg. *Protoplasma*, 44: 377–384.

HOFFMANN-BERLING, H. 1954a. Adenosintriphosphat als Betriebsstoff von Zellbewegungen. *Biochim. biophys. Acta*, 14: 182–194.

——. 1954b. Die Bedeutung des Adenosintriphosphat fur die Zell- und Kernteilungsbewegungen in der Anaphase. *Biochim. biophys. Acta*, 15: 226–236.

——. 1954c. Die Glycerin-wasserextrahierte Telophasezelle als Modell der Zytokinese. *Biochim. biophys. Acta*, 15: 332–339.

——. 1955. Geiselmodelle und Adenosintriphosphat (ATP). *Biochim. biophys. Acta*, 16: 146–154.

——, and H. H. WEBER. 1953. Vergleich der Motilität von Zellmodellen und Muskelmodellen. *Biochim. biophys. Acta*, 10: 629–645.

HOGEBOOM, G. H. 1951. Separation and properties of cell components. *Fed. Proc.*, 10: 640–645.

——, and E. L. KUFF. 1955. Relation between cell structure and cell chemistry. *Fed. Proc.*, 14: 633–638.

HOLTER, H. 1952. Localization of enzymes in cytoplasm. *Advanc. Enzymol.*, 13: 1–20.

HOLTFRETER, J. 1954. Observations on the physicochemical properties of isolated nuclei. *Exp. Cell. Res.*, 7: 95–102.

HORN, E. C. 1956. Ascites tumor development. II. Cytotoxicity of various antisera prepared against Ehrlich ascites tumor cell components. *Cancer Res.*, 16: 595–599.

HOSTER, M. S., B. J. MCBEE, H. A. ROLNICK, Q. VAN WINKLE, and H. A. HOSTER. 1950. Marcomolecular particles obtained from human neoplastic and non-neoplastic lymph nodes. I. Procedure and preliminary results. *Cancer Res.*, 10: 530–538.

HUGHES, A. 1952. *The Mitotic Cycle*. Academic Press, Inc., New York.

HULTIN, T. 1950. Incorporation in vivo of N^{15}-labelled glycine into liver fractions of newly hatched chicks. *Exp. Cell Res.*, 1: 376–381.

INOUÉ, S. 1952. The effect of colchicine on the microscopic and the submicroscopic structure of the mitotic spindle. *Exp. Cell Res.*, Suppl. 2: 305–314.

——, and K. DAN. 1951. Birefringence of the dividing cell. *J. Morph.*, 89: 423–456.

JACOBSON, W., and M. WEBB. 1952. The two types of nucleoproteins during mitosis. *Exp. Cell Res.*, 3: 163–183.

JAGGI, M. P., and D. F. WAUGH. 1950. Structure of gels from ovalbumin and serum albumin. *Fed. Proc.*, 9: 66.

JOHNSON, F. H., H. EYRING, and M. J. POLISSAR. 1954. *Kinetic Basis of Molecular Biology*. John Wiley & Sons, New York.

JOLY, M. 1949a. Étude par la biréfringence d'écoulement de la gélification de la gélatine et de ses interactions avec d'autres substances organiques. *Bull. Soc. Chim. biol. Paris*, 31: 105–107.

——. 1949b. Untersuchungen über die Umwandlungen einiger kolloider Systeme mit Hilfe der Strömungsdoppelbrechung. *Kolloidzschr.*, 115: 83–89.

——, and E. BARBU. 1949. Étude par la biréfringence d'écoulement de la denaturation termique de la sérumalbumine. *Bull. Soc. Chim. biol. Paris*, 31: 1642–1655

——, and ——. 1951. Étude par la biréfringence d'écoulement de l'agrégation thermique de la sérumalbumine. *J. chem. Phys.*, 48: 636–642.

——, and B. RYBAK. 1950. Recherches sur la constitution du fuseau archromatique. II. Études rheologiques de quelques modèles protéiques. *Bull. Soc. Chim. biol. Paris*, 32: 894–903.

——, G. SCHAPIRA, and J. C. DREYFUS. 1955. Length of myosin particles in dilute solutions determined by flow birefringence. *Arch. Biochem. Biophys.*, 59: 165–180.

KATCHALSKY, A. 1954. Polyelectrolyte gels. In *Progress in Biophysics and Biophysical Chemistry*, Vol. IV (J. A. V. Butler and J. T. Randall, eds.), pp. 1–59. Academic Press, New York.

KATER, J. M. 1937. The liver-blood fluid exchange

and the morphology of hepatic cell mitochondria. *J. Morph.*, 61: 473–484.

KELLER, E. B. 1951. Turnover of proteins of cell fractions of adult rat liver *in vivo*. *Fed. Proc.*, 10: 206.

KLECZKOWSKI, A. 1949. A quantitative study of complex formation in heated protein mixtures. *Biochem. J.*, 44: 573–581.

KRUYT, H. R. (ed.). 1949. *Colloid Science*. Vol. II. *Reversible Systems*. Elsevier Press, New York.

KUHN, W., B. HARGITAY, A. KATCHALSKY, and H. EISENBERG. 1950. Reversible dilation and contraction by changing the state of ionization of high-polymer acid networks. *Nature, Lond.*, 165: 514–516.

LANDAHL, H. D. 1942. An analysis of the shapes of a cell during division with particular reference to the role of surface tension. *Bull. math. Biophys.*, 4: 131–134.

——. 1942b. Equilibrium shapes in non-uniform fields of concentration. *Bull. math. Biophys.*, 4: 155–158.

——. 1942c. A kinetic theory of diffusion forces in metabolizing systems. *Bull. math. Biophys.*, 4: 15–26.

——. 1942d. A mathematical analysis of elongation and constriction in cell division. *Bull. math. Biophys.*, 4: 45–62.

LANG, K. 1952. Lokalisation der Fermente und Stoffwechselprozesse in den einzelnen Zellbestandteilen und deren Trennung. In *Mikroskopische und chemische Organization der Zelle*, pp. 24–42 (2. Colloquium der Deutschen Gesellschaft für physiologische Chemie). Springer-Verlag, Berlin.

LETTRÉ, H. 1951. Zellstoffwechsel und Zellteilung. *Naturwissenschaften*, 21: 490–496.

——. 1952. Some investigations on cell behavior under various conditions: A review. *Cancer Res.*, 12: 847–860.

LEWIS, M. R. 1923. Reversible gelation in living cells. *Johns Hopk. Hosp. Bull.*, 34: 373–379.

LEWIS, W. H. 1951. Cell division with special reference to cells in tissue cultures. *Ann. N. Y. Acad. Sci.*, 51: 1287–1294.

LOEB, L., and M. BLANCHARD. 1922. The effect of various salts on the outgrowth from experimental amoebocyte tissue near the isoelectric point and with the addition of acid or alkali. *Amer. J. Physiol.*, 60: 277–307.

LITTLEFIELD, J. W., E. B. KELLER, J. GROSS, and P. C. ZAMECNIK. 1955. Studies on cytoplasmic ribonucleoprotein particles from the liver of the rat. *J. biol. Chem.*, 217: 111–123.

LORAND, L. 1954. Interaction of thrombin and fibrinogen. *Physiol. Rev.*, 34: 742–752.

LUNDGREN, H. P. 1949. Synthetic fibers made from proteins. *Advanc. Protein Chem.*, 5: 305–351.

MACKLER, B., and D. E. GREEN. 1956. Studies on the electron transport system. II. On the "opening" phenomenon. *Biochim. biophys. Acta*, 21: 1–6.

MALMGREN, R. A., B. E. BENNISON, B. F. ANDERSON, and C. C. RISLEY. 1951. A serologic study of the microsome fraction of normal and neoplastic mouse tissues. *J. nat. Cancer Inst.*, 11: 1277–1286.

MARSLAND, D. A. 1939. The mechanism of cell division. Hydrostatic pressure effects upon dividing egg cells. *J. cell. comp. Physiol.*, 13: 15–22.

——. 1942. Protoplasmic streaming in relation to gel structure in the cytoplasm. In *American Society of Plant Physiologists Symposium on Structure of Protoplasm* (W. Seifriz, ed.), pp. 127–161. Iowa State College Press, Ames.

——. 1951. The action of hydrostatic pressure on cell division. *Ann. N. Y. Acad. Sci.*, 51: 1327–1335.

——, and D. E. S. BROWN. 1936. Amoeboid movement at high hydrostatic pressure. *J. cell. comp. Physiol.*, 8: 167–178.

——, and ——. 1942. The effects of pressure on sol-gel equilibria, with special reference to myosin and other protoplasmic gels. *J. cell. comp. Physiol.* 20: 295–305.

——, and J. V. LANDAU. 1954. The mechanism of cytokinesis: Temperature-pressure studies on the cortical gel system in various marine eggs. *J. exp. Zool.*, 125: 507–539.

MAZIA, D. 1956. Materials for the biophysical and biochemical study of cell division. *Advanc. biol. med. Phys.*, 4: 99–118.

——, and K. DAN. 1952. The isolation and biochemical characterization of the mitotic apparatus of dividing cells. *Proc. Nat. Acad. Sci., Wash.*, 38: 826–838.

——, and J. D. ROSLANSKY. 1956. The quantitative relations between total cell proteins and proteins of the mitotic apparatus. *Protoplasma*, 46: 528–534.

MINSHALL, W. H., and G. W. SCARTH. 1952. Effect of growth in acid media on the morphology, hydrogen-ion concentration, viscosity, and permeability of water hyacinth and frogbit root cells. *Canad. J. Bot.*, 30: 188–208.

MITCHISON, J. M. 1952. Cell membranes and cell division. *Symp. Soc. exp. Biol.*, 6: 105–127.

——, and M. M. SWANN. 1954a. The mechanical properties of the cell surface. I. The cell elastimeter. *J. exp. Biol.*, 31: 443–458.

——, and ——. 1954b. The mechanical properties of the cell surfaces. II. The unfertilized sea-urchin egg. *J. exp. Biol.*, 31: 461–472.

MONNÉ, L. 1946. Action of narcotics and of hydration and dehydrating agents on the structure of the cytoplasm. *Ark. Zool.*, 39A (7): 1–32.

——. 1948. Functioning of the cytoplasm. *Advanc. Enzymol.*, 8: 1–69.

——, and D. B. Slautterback. 1950. Differential staining of various polysaccharides in sea urchin eggs. *Exp. Cell Res.*, 1: 477–491.

Monty, K. J., M. Litt, E. R. M. Kay, and A. L. Dounce. 1956. Isolation and properties of liver cell nucleoli. *J. biochem. biophys. Cytol.*, 2: 127–145.

Morales, M. F., J. Botts, J. J. Blum, and T. L. Hill. 1955. Elementary processes in muscle action: An examination of current concepts. *Physiol. Rev.*, 35: 475–505.

Najjar, V. A., and J. Fisher. 1956. The mechanism of antibody-antigen reaction. *Biochim. biophys. Acta*, 20: 158–169.

Newburgh, R. W., and V. H. Cheldelin. 1956. The intracellular distribution of pentose cycle activity in rabbit kidney and liver. *J. biol. Chem.*, 218: 89–96.

Oster, G. 1950. Two-phase formation in solutions of tobacco mosaic virus and the problem of long range forces. *J. gen. Physiol.*, 33: 445–473.

Pease, D. C. 1941. Hydrostatic pressure effects upon the spindle figure and chromosome movement. I. Experiments on the first mitotic division of *Urechis* eggs. J. Morph., 69: 405–441.

——. 1946. Hydrostatic pressure effects upon the spindle figure and chromosome movement. II. Experiments on the meiotic divisions of *Tradescantia* pollen mother cells. *Biol. Bull., Woods Hole*, 91: 145–169.

Pfeiffer, H. H. 1954. Beiträge zur Cytochemie des isolierten Atraktoplasma von Spermatocyten *in vitro*. *La Cellule*, 56: 243–249.

Pollister, A. W. 1939. Centrioles and chromosomes in the atypical spermatogenesis of *Vivipara*. *Proc. Nat. Acad. Sci., Wash.*, 25: 189–195.

——, and H. Ris. 1947. Nucleoprotein determination in cytological preparations. *Cold Spr. Harb. Symp. quant. Biol.*, 12: 147–157.

Potter, V. R., R. O. Recknagel, and R. B. Hurlbert. 1951. Intracellular enzyme distribution, interpretation and significance. *Fed. Proc.*, 10: 646–653.

Rashevsky, N. 1938. *Mathematical Biophysics. Physico-mathematical Foundations of Biology*. The University of Chicago Press, Chicago.

——. 1939. The mechanism of cell division. *Bull. math. Biophys.*, 1: 23–30.

Rees, A. L. G. 1951. Directed aggregation in colloidal systems and the formation of protein fibers. *J. phys. Chem.*, 55: 1340–1344.

Ris, H. 1949. The anaphase movement of chromosomes in the spermatocytes of the grasshopper. *Biol. Bull., Woods Hole*, 96: 90–106.

——. 1955. Cell division. In *The Analysis of Development* (B. H. Willier, P. A. Weiss, and V. Hamburger, eds.), pp. 91–125. W. B. Saunders Company, Philadelphia.

——, and R. Kleinfeld. 1952. Cytochemical studies on the chromatin elimination in *Solenobia* (Lepidoptera). *Chromosoma*, 5: 363–371.

Riseman, J., and J. G. Kirkwood. 1948. Remarks on the physico-chemical mechanism of muscular contraction and relaxation. *J. Amer. chem. Soc.*, 70: 2820–2822.

Roberts, H. S. 1949. Changes in mitochondrial form. *Anat. Rec.*, 104: 163–188.

——. 1955. The mechanism of cytokinesis in neuroblasts of *Chortophaga viridifasciata* (De Geer). *J. exp. Zool.*, 130: 83–105.

——, and N. G. Anderson. 1951. Studies on isolated cell components. III. A cytological study of the effects of heparin on isolated nuclei. *Exp. Cell Res.*, 2: 224–234.

Rozsa, G., A. Szent-Györgyi, and R. W. G. Wyckoff. 1949. The electron microscopy of F-actin. *Biochim. biophys. Acta*, 3: 561–569.

Runnström, J. 1949. The mechanism of fertilization in metazoa. *Advanc. Enzymol.*, 9: 241–327.

——. 1955. Changes in the submicroscopic structure of the cytoplasm attending maturation and activation of the sea urchin egg. *Exp. Cell Res.*, 8: 49–61.

Bybak, B. 1950. Recherches sur la constitution du fuseau achromatique. I. Étude chimiques de quelques modèles proteiques. *Bull. Soc. Chim. biol.* Paris, 32: 703–718.

Schechtman, A. M., and T. Nishihara. 1955. The cell nucleus in relation to the problem of cellular differentiation. *Ann. N. Y. Acad. Sci.*, 60: 1079–1094.

Schneider, W. C. 1946. The action of ribonuclease on the succinoxidase system. *J. biol. Chem.*, 164: 241–247.

——. 1953. Biochemical constitution of mammalian mitochondria. *J. Histochem. Cytochem.*, 1: 212–233.

——, and G. H. Hogeboom. 1951. Cytochemical studies of mammalian tissues: the isolation of cell components by differential centrifugation. A review. *Cancer Res.*, 11: 1–22.

——, and ——. 1956. Biochemistry of cellular particulates. *Ann. Rev. Biochem.*, 25: 201–224.

Schrader, F. 1936. The kinetochore or spindle fiber locus in *Amphiuma tridactylum*. *Biol. Bull., Woods Hole*, 70: 484–498.

——. 1953. *Mitosis. The movements of chromosomes in cell division* (2nd ed.). Columbia University Press, New York.

Seifriz, W. 1953. Mechanism of protoplasmic movement. *Nature, Lond.*, 171: 1136–1138.

Selby, C. C. 1953. Electron micrographs of mitotic cells of the Ehrlich mouse ascites tumor in thin sections. *Exp. Cell Res.*, 5: 386–393.

SINGER, S. J. 1955. On the chemical structure of the reactive sites of antibody molecules. *Proc. Nat. Acad. Sci., Wash.*, 41: 1041–1045.

SOROF, S., and P. P. COHEN. 1951. Electrophoretic studies of the soluble proteins of rabbit liver. *J. biol. Chem.*, 190: 303–309.

STERN, H., and A. E. MIRSKY. 1953. Soluble enzymes of nuclei isolated in sucrose and non-aqueous media. *J. gen. Physiol.*, 37: 117–187.

STICH, H. 1951a. Das Vorkommen von Kohlenhydraten im Ruhekern und während der Mitose. *Chromosoma*, 4: 429–438.

——. 1951b. Das Vorkommen von Ribonucleinsaüre in Kernsaft und Spindel sich teilender Kerne von *Cyclops strenuus*. *Z. Naturf.*, 6b: 259–261.

SUOMALAINEN, H. O. T. 1954. Effect of colchicine on spermatogenesis in certain grasshoppers. *Exp. Cell Res.*, 7: 563–564.

SWANN, M. M. 1951a. Protoplasmic structure and mitosis. I. The birefringence of the metaphase spindle and asters of the living sea-urchin egg. *J. exp. Biol.*, 28: 417–433.

——. 1951b. Protoplasmic structure and mitosis. II. The nature and cause of birefringence changes in the sea-urchin egg at anaphase. *J. exp. Biol.*, 28: 434–444.

——. 1952a. The nucleus in fertilization mitosis and cell division. *Symp. Soc. exp. Biol.*, 6: 89–104.

——. 1952b. Structural agents in mitosis. *Int. Rev. Cytol.*, 1: 195–216.

——. 1954. The mechanism of cell division: Experiments with ether on the sea urchin egg. *Exp. Cell Res.*, 7: 505–517.

TOBIAS, J. M., and S. SOLOMON. 1950. Electrically induced polar changes in viscosity in the hyaline protoplasm of *Elodea* with observations on streaming and plastid charge. *J. cell. comp. Physiol.*, 35: 1–9.

USHER, F. L. 1929. A mechanism of gelatinization. *Proc. roy. Soc.*, A, 125: 143–151.

VERWEY, E. J. W., and J. T. G. OVERBEEK. 1948. *Theory of the Stability of Lymphobic Colloids*. Elsevier Press, New York.

WADA, B. 1950. The mechanism of mitosis based on studies of the submicroscopic structure and of the living state of the *Tradescantia* cell. *Cytologia (Tokyo)*, 16: 1–26.

——. 1955. Some problems on the mitotic figures studied in the living cell. *Caryologia*, 7: 389–403.

WADDINGTON, C. H. 1954. The cell physiology of early development. In *Recent Developments in Cell Physiology* (J. A. Kitching, ed.). pp. 105–119. [*Proc. Seventh Symposium of the Colston Research Society.*] Butterworths Scientific Publications, London.

WATSON, M. L. 1955. The nuclear envelope. Its structure and relation to cytoplasmic membranes. *J. biophys. biochem. Cytol.*, 1: 257–270.

WAUGH, D. F. 1941. The properties of protein fibers produced reversibly from soluble protein molecules. *Amer. J. Physiol.*, 133: 484–485.

——. 1946. A fibrous modification of insulin. I. The heat precipitate of insulin. *J. Amer. chem. Soc.*, 68: 247–250.

——, and B. J. LIVINGSTONE. 1951. Kinetics of the interactions of bovine fibrinogen and thrombin. *J. phys. Chem.*, 55: 1206–1218.

WEBER, H. H. 1955. Kontraktile Proteins und Motilität der Lebewesen. *Naturwissenschaften*, 42: 270–275.

WEIMAR, V. L. 1953. Calcium binding in frog muscle brei. *Physiol. Zool.*, 26: 231–242.

WEIL, M. L., J. WARREN, S. S. BREESE, S. B. RUSS, and H. JEFFRIES. 1952. Separation of encephalomyocarditis virus from tissue components by means of protamine precipitation and enzymatic digestion. *J. Bact.*, 63: 99–105.

WIERCINSKI, F. J. 1944. An experimental study of protoplasmic pH determination. I. Amoebae and *Arbacia punctulata*. *Biol. Bull., Woods Hole*, 86: 98–112.

WILKIE, D. R. 1954. Facts and Theories about Muscle. In *Progress in Biophysics and Biophysical Chemistry*, Vol. IV (J. A. V. Butler and J. T. Randall, eds.), pp. 288–324. Academic Press, New York.

WILLIAMSON, M. B., and A. GULICK. 1942. The estimation of alkaline earth minerals in thymus nuclei. *J. cell. comp. Physiol.*, 20: 116–118.

WOODIN, A. M., and S. A. BOBUCHOFF. 1955. Particle interaction in solutions derived from ox vitreous humor. *J. biophys. biochem. Cytology*, 1: 489–500.

ZBARSKII, I. B., and S. S. DEBOV. 1948. On cell-nucleus proteins. *Dokl. Akad. Nauk SSSR*, 62: 795–798. (In Russian).

——, and ——. 1951. Protein fractions of cell nuclei. *Biokhimii*, 16: 390–395. (In Russian).

——, and K. A. PEREVOSHCHIKOVA. 1948. On certain properties of cell-nucleus albumens. *Dokl. Akad. Nauk SSSR*, 60: 77–80. (In Russian).

——, and ——. 1951a. Contractile properties of cell nucleus albumens. *Biokhimii*, 16: 112–124. (In Russian).

——, and ——. 1951b. The nature of the contractile substance of the cell nucleus. *Biokhimii*, 16: 547–555. (In Russian).

EVOLUTION AND BIOLUMINESCENCE

By E. NEWTON HARVEY

Biology Department, Princeton University

This review is a more detailed version of a presidential address delivered before the American Society of Naturalists at the University of Connecticut, Storrs, Connecticut, in August, 1956. Further information regarding luminous animals will be found in the author's book, *Bioluminescence* (1952).

INTRODUCTION

MOST laymen, and indeed many scientists, do not realize how widespread throughout the living world is the property of producing light—bioluminescence (see Harvey, 1952, 1955). In the plant kingdom, the cells of two orders (bacteria and fungi) display luminosity, while among animals, luminous species are found in some 40 different groups, from the simplest protozoa to the chordates, where a large number of teleost fish have developed the most perfect lighting system, controlled by nerves or endocrines. A glance at an evolutionary tree will reveal luminous species scattered in about half of the phyla, with no apparent rhyme or reason. Some phyla possess many, others few luminous species. It is possible that all individuals among the Ctenophora are luminous; certainly a very large number of them emit light. Many of the Cnidaria are luminescent, whereas in the phylum Nemertinea only one luminous species is known. Among the Mollusca, luminescence is widespread in the Cephalopoda, whereas luminous snails, bivalves, and nudibranchs are rare. Thus, in the course of evolution, light production has appeared again and again. The origin of this widespread luminosity presents a fascinating problem. Why should the distribution be "spotty" rather than following direct evolutionary lines?

It is with some trepidation that I have selected "Evolution and Bioluminescence" as a title for a presidential address—first, because I am not fundamentally a student of evolution, and second, because those who have written on the subject have found the evolution of complex structures for light emission very hard to explain. Darwin, in later editions of *The Origin of Species*, under the heading, "Special Difficulties of the Theory of Natural Selection," placed luminous organs of insects in the same category as the electric organs of fish, and merely wrote, "it is impossible to conceive how these wondrous organs have been produced."

This statement is in the first edition (1859) in reference to electric organs, but luminous organs of insects are not mentioned until the fourth edition (1866), and the same statement applied to them.

One difficulty was lack of knowledge of the use of luminous organs. There have been many suggestions regarding their purpose, but little experimentation. Darwin himself in later editions of *The Descent of Man* (1874), in speaking of sexual selection, discussed the value of light to the female (European) glow-worm. The lighting ability has usually been considered a signal to attract the flying male, but Darwin adopted a use suggested by T. Belt in *The Naturalist in Nicaragua* (1874), that of a warning signal. The lampyrid beetles, to which the glow-worm belongs, appear to be distasteful to insectivorous mammals and birds. Therefore, Darwin wrote, "the luminous species profit by being at once recognized as unpalatable. . . . It is not known why the wings of the female glow-worm have not been developed; but in her present state she closely resembles a larva, and as larvae are so largely preyed on by many animals, we can understand why she has been rendered so much more luminous and conspicuous than the male; and why the larvae themselves are likewise luminous." Wallace used practically the same argument in *Tropical Nature and other Essays* (1878).

So far as the author is aware, Lamarck did not discuss the origin of bioluminescence, nor have neo-Lamarckians tackled the problem, although surely it might be argued that a change from diurnal to

nocturnal habits, or a movement from the surface to the dark depths of ocean would be a powerful environmental factor to call forth any latent tendency to emission of light, and certainly any desire to have a light.

Weismann, in later years, held that the development of photophores in such diverse groups (shrimp, squid, and fish) as adaptations to the darkness of great depths left "no possibility of referring them to sudden mutations which have arisen all at once in these groups with no relation to utility, and yet have not occurred in any animals living in the light. Only 'variations' progressing and combining in the direction of utility can give us the key to an explanation of the origin of such structures." This quotation is from the J. A. Thomson translation of A. Weismann, *The Evolution Theory*, 1904, Vol. 2, p. 322.

Later evolutionists have had little more success than Darwin in visualizing the evolution of luminous organs. Although Goldschmidt (1948) has called attention to the adaptations of the New Zealand glow-worm, a discussion of bioluminescence is mostly absent from modern treatments.

In addition to actual seeing, sex attraction, and warning, other uses for the ability to emit light might be attraction of food, i.e., as lures in the case of the deep-sea angler-fish; or as recognition marks for members of one species, perhaps to keep a school of deep-sea fish together; or to confuse a predator, as by excreting a luminous fluid and immediately swimming off in another direction. Such a purpose is conceivable in the deep-sea squid, *Heteroteuthis*, which possesses only a rudimentary ink gland and might use its luminous secretion in darkness for the same purpose that surface forms use ink. Rather than hiding in a cloud of inky water, surface squid become colorless and eject a squid-shaped mass of black ink which attracts the attention of a predator, while the squid removes itself from the scene. This habit of ejecting luminous material and moving away appears to have been adopted by the deep-sea *Heteroteuthis*, which could hardly hide in a cloud of luminous material.

Space does not permit a discussion of the many enigmas presented by the emission of light by certain organisms. Of what use can light be to a luminous bacterium or to the mycelium of a fungus which grows on dead logs or tree stumps? What use can be made of the light of the myriad dinoflagellates, or of ctenophores or jelly-fishes which float at the surface of the sea, and give rise to that "phosphorescence" which has so intrigued the poet and mystified the scientist? The problem becomes even more difficult when it is realized that these plankton forms luminesce only when disturbed, as by the breaking of waves.

Of what use can light be to a worm, *Chaetopterus*, which lives its whole life in a sickle-shaped parchment tube, buried in the mud, with only the two open ends of the tube reaching above the surface to allow passage of a current of sea water? Observation at the Marine Biological Laboratory, Woods Hole, Mass. indicates that *Chaetopterus pergamentaceous*, kept in aquaria in U-shaped glass tubes simulating their parchment tubes, occasionally secrete considerable luminous material when disturbed. This luminous fluid passes out one end of the tube by paddle movement, and appears as a faint glow, which might frighten a predator. Or why should a boring mollusc, *Pholas dactylus*, have developed several glandular luminous spots, when it also lives most of its life deep in the solid rock? These are questions for every proponent of natural selection, and they no doubt presented serious obstacles to Darwin and other evolutionists in endeavoring to explain the origin of species.

It will be recalled that among the "difficulties" in visualizing how evolution might be explained by natural selection, Darwin placed the first beginnings of an extremely complicated structure. How could the start of an organ such as the eye, highly useful in its perfected form, be of survival value? It was in this connection that he gave up the attempt to explain light organs and electric organs.

Thus, there are two problems in the evolution of any unusual ability of animals, (1) the first beginnings, and (2) the subsequent complications which lead to a perfected organ. In order to see, there must be a photosensitive pigment, but the appearance of such a pigment and the perfection of an image-forming vertebrate eye is a long step, just as the simple material used by bacteria to luminesce is far removed from the rows of lanterns of a deep-sea fish.

It is obviously necessary in light production to have some compound which will emit light, a photogen, and this substance must either come from a precursor, or be reformed from its reaction products, i.e., the luminescent reaction must be reversible. In the course of evolution accessory complications of structure may control the light produced, turning it on or off, or sending it in a certain direction. Therefore it will be convenient to divide this discussion of the evolution of bioluminescence into two parts—the first dealing with the

chemical light-producing reactions of various groups of organisms, and the second concerned with particularly interesting aspects of light-production throughout the living world, facts which bear on the evolution of light organs in relation to the habits of various luminous animals.

THE BEGINNINGS OF LIGHT-PRODUCTION

Nearly twenty-five years ago I presented a paper before the American Philosophical Society on "The Evolution of Bioluminescence," to which was added the phrase "and its Relation to Cell Respiration" (Harvey, 1932; see also 1953). The gist of the argument was presented in the third paragraph:

"In the lowest and simplest luminous forms, the luminous bacteria, I believe the luminous mechanism is part of the respiratory mechanism and that the development of luminosity in the animal kingdom represents a specialization of one phase of the respiratory process, namely the development of special hydrogen acceptors."

It is a satisfaction to realize that recent work has amply verified this prediction, and that it is now possible to designate chemically the compound which is responsible for the emission of light by bacteria. The bacterial photogen appears to be reduced flavin mononucleotide ($FMNH_2$), and the continuous light-production of luminous bacteria occurs during one step in the respiratory chain of oxidations characteristic of cells in general. The process can now be imitated in a test tube with pure substances whose chemical structure is well known, with the single exception of the enzyme luciferase, which must be extracted from bacterial cells. Thus we now have the information to discuss from an evolutionary point of view the first beginnings of an organ which in many higher animals evolved to a complicated lantern with lens, reflector, and opaque and color screens.

The first question regarding the beginnings of light-emission in various groups is whether the same chemical compounds and chemical reactions have been utilized. The answer is a decided, No! Although the chemistry of light-emission in all the 40-odd groups of light-producing organisms has not been studied, the reactions involved in three groups are understood in some detail, and they are all different. These groups are the luminous bacteria, the fire-flies, and a small ostracod crustacean, *Cypridina*.

Since Dubois (1887) named the light-emitting compound "luciférine" and the enzyme connected with light-production "luciférase," it has been customary to regard these two compounds, together with oxygen and water, as the chief photogenic substances. In *Cypridina*, no other accessory substances have yet been discovered; mixing pure luciferin and luciferase solutions containing oxygen results in the production of light. The chemical structure of *Cypridina* luciferin is not yet known but it appears to be a chromopolypeptid (Mason, 1952). It is yellow in color, with weakly yellow fluorescence, and changes to a colorless, less fluorescent oxidation product during the emission of light. The chemistry has recently been discussed by Tsuji, Chase, and Harvey (1955) and by Tsuji (1955).

Cypridina luciferin and luciferase are both different from corresponding compounds in the photogenic cells of the fire-fly. In addition to luciferin and luciferase, fire-fly luminescence also requires the presence of adenosine triphosphate (ATP) and magnesium ions, as well as oxygen and water. The complicated reactions involved have been studied by McElroy and Hastings (1955), by Strehler (1955), by Green and McElroy (1956), and by McElroy and Green (1955, 1956). The two last workers have crystallized fire-fly luciferase. Fire-fly luciferin (empirical formula, $C_{13}H_{12}N_2S_2O_3$) has also been crystallized (W. D. McElroy, pers. commun.) but its structure is as yet unknown.

The mechanism of light-production is visualized as follows: fire-fly luciferin, ATP, Mg^{++}, and luciferase are believed to combine to form an active intermediate, (adenyl-luciferin) which emits light in the presence of oxygen. Pyrophosphatase favors the formation of an inactive complex by attachment to the surface of the enzyme. Pyrophosphate releases this inhibition and consequently is regarded by McElroy and Hastings as the trigger, converting the inactive complex to the active intermediate during the flash of a fire-fly. The flash is nerve-controlled, and pyrophosphate is believed to be liberated indirectly by the action of acetylcholine from nerve endings. The acetic acid produced from the splitting of acetylcholine liberates pyrophosphate from ATP. Thus, not only the chemistry but also the control over the light is accounted for.

The more complicated chemistry existing in the fire-fly, as compared with *Cypridina*, appears to be connected with the fact that the emission of light in the fire-fly is intracellular, and that a special stimulating mechanism is involved. The simple condition in *Cypridina* results from the extracellular luminescence of that form. Luciferin and

luciferase are manufactured in different gland cells and simultaneously squeezed into the sea water by muscle fibers, which receive the innervation.

A third situation with a wholly different light-producing mechanism exists in luminous bacteria, and presumably in fungi also, although this has not yet been proven. These plants produce light continually; they are quite independent of stimulation. The luminescence is intracellular, but Strehler and Cormier (1953) have succeeded in obtaining cell-free luminous extracts. Five substances—reduced flavin mononucleotide ($FMNH_2$), a long-chain aldehyde, bacterial luciferase, oxygen, and water—are necessary for light production (see Strehler, 1955). Mixing these five in a test tube results in a flash of light (Strehler, Harvey, Chang, and Cormier, 1954).

In the cell continuous luminescence involves the continuous production of $FMNH_2$ by the action of reduced diphosphopyridine nucleotide (DPNH) in the presence of diphosphopyridine nucleotide oxidase. This continuous emission of light can be established in vitro. Cormier, Totter, and Rostorfer (1956) have shown that the latter action in oxidizing DPNH is different from the light-producing luciferase action of bacterial cell extracts. Bacterial luciferin is reduced flavin mononucleotide, perhaps combined with aldehyde. Bacterial luciferase is regarded by McElroy and Green (1955) and by Totter and Cormier (1955) as a flavoprotein enzyme which contains one FMN prosthetic group firmly bound, and which oxidizes an $FMNH_2$—long-chain-aldehyde complex, with emission of light, at another site on the enzyme.

It will be at once recognized that the pyridine nucleotides, the flavins, and the flavoproteins are initial members of the same respiratory chain, that involves cytochromes and cytochrome oxidase, by which food-stuffs are oxidized in the cell. That is, the light-emitting system in bacteria is part of the hydrogen acceptor respiratory pathway of cells in general.

Moreover, the reversible nature of the oxidized and reduced prosthetic groups in the respiratory oxidizing enzymes indicates how a steady state condition can be attained in a bacterial cell, and result in the constant emission of light. Flavin mononucleotide has a reversible redox potential, and it appears fairly certain that the oxidation of $FMNH_2$ in the presence of long-chain aldehydes by bacterial luciferase, the reaction which is accompanied by an emission of light, is reversible, although the aldehyde may go to an acid (McElroy and Green, 1955, 1956).

The author (Harvey, 1918) called attention to the reversibility of oxidized *Cypridina* luciferin, provided the reduction was carried out quickly, before an irreversible oxidative step occurred; and again stressed the importance of luciferin–oxyluciferin reversibility in an address before the Illuminating Engineering Society in 1921 (Harvey, 1921). However, the fact that *Cypridina* secretes the luminescent material into the sea water makes a reduction of the oxidized product unnecessary in the economy of this animal.

It would be of great interest to know how many other chemical types of luminescence exist in the animal kingdom. Luciferin from one group of luminous animals will not react with the luciferase from another, and vice versa (Harvey, 1926), a result previously attributed to slight differences in the various luciferases or luciferins, comparable to specificity of proteins. It now appears that the luciferins are wholly different organic compounds, and that the mechanisms of light-production are dissimilar in different luminous organisms. Rather than making use of slightly different luciferins for light-production, during the course of evolution widely separated groups of animals have adopted compounds whose structure differs as much as the oxygen-carrying blood pigments, hemoglobin and hemocyanin. In more closely related organisms, such as different species of fire-flies, the luciferin might be comparable to the anthocyan pigments of plants, all of which are derived from the pelargonidin nucleus by substitution of simple groups (methyl, methyloxy, hydroxyl, etc.) in different positions. As Scott-Moncrieff (1936) has shown, these substitutions are controlled by separate genes.

As early as 1938, Komarek and Wenig associated light-production in earthworms with riboflavin. In 1949, Wenig and Kubista found riboflavin in the luminous lymphocytes of *Eisenia montana* and also in the non-luminous lymphocytes of *Eisenia foetida*, and hence concluded that some other factor must be present to account for light-production in the luminous species and the absence of light in the dark species. It is obvious that earthworm chemistry should be reinvestigated, as well as the chemistry of light-production among myriapods, the mollusc *Pholas dactylus*, the ctenophores, and some of the coelenterates, all of which can be obtained or cultivated in quantity.

When Darwin discussed the first beginnings of

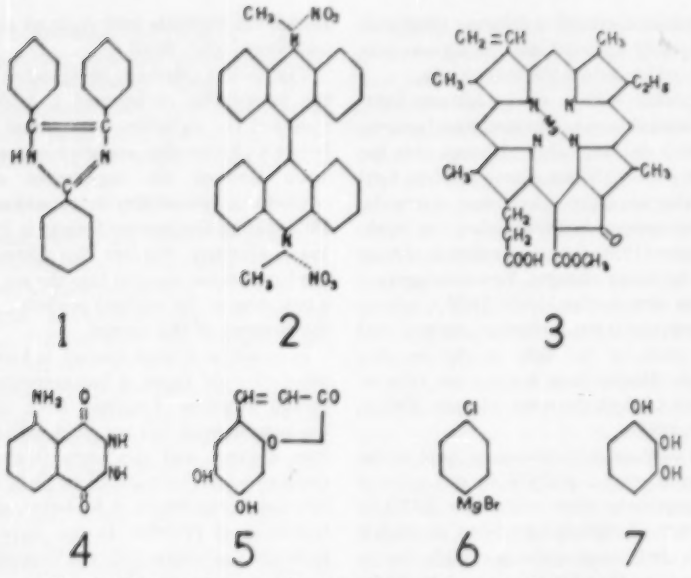

FIG. 1. VARIOUS TYPES OF ORGANIC CHEMILUMINESCENCE COMPOUNDS

1, Lophin, or triphenylglyoxaline. 2, Dimethyldiacridinium nitrate. 3, A metal porphyrin compound. 4, Luminol, or aminophthalic hydrazide. 5, Aesculetin, present in the glucoside aesculin. 6, Chlorphenylmagnesium bromide. 7, Pyrogallol [From Harvey, 1952.]

light organs the large number of chemiluminescent organic compounds now available was unknown. The principal chemiluminescent substance was the element phosphorus, and most theories of the early nineteenth century supposed that animal light was due to a phosphorus compound. The work of Radziszewsky (1877, 1880, 1883) called attention to various methods of obtaining luminescence from essential oils and from such pure materials as amarin, lophin, etc., by oxidation. At the present time the most diverse groups of organic substances can be made to chemiluminesce, with all colors of the spectrum from red to blue, thus imitating the various spectral characteristics of the light of luminous animals (see Fig. 1).

NON-LUMINOUS AND LUMINOUS MUTANTS

There can be little doubt that luminescence has appeared in different groups at one time or another during the course of evolution by a slight change in one of the various compounds necessary for the life of the cell, most likely some compound connected with a respiratory step. Additional evidence in favor of this view comes from the observation that in many orders of luminous organisms two varieties or species, morphologically closely related, are found, one of which is luminous and the other not.

The clearest examples occur among luminous bacteria, where non-luminous strains or mutants have been known for a long time. It was Beijerinck (1900) who first realized the significance of this fact. In a paper, "On Different Forms of Hereditary Variation of Microbes," he referred to the interesting lecture by Hugo de Vries on the origin of new species of plants—one of the early statements of the mutation theory, presented at the previous meeting of the Academy of Sciences of Amsterdam. De Vries' lecture induced Beijerinck to draw attention to some observations concerning the same subject in microbes. As early as 1889, he had noticed that old cultures of luminous bacteria would sometimes emit only a weak light, or no light at all, when inoculated on a new medium. In 1900, he referred to three types of change in bacterial colonies: (1) by degeneration, when all individuals of a colony cease to grow and die out; (2) by transformation of all individuals into a rapidly growing but dark colony, with occasional appearance of a bright variant; and (3) by common variation in some individuals, which might form dim or dark colonies. It was the third process

which Beijerinck compared to de Vries' sudden mutations of *Oenothera*, and he agreed that such mutations were responsible for the origin of species.

In a later, extensive paper, "Mutation bei Microben," Beijerinck (1912) described in detail the various mutants of luminous bacteria and of other bacteria, and in 1917 he published a paper on "The Enzyme Theory of Heredity," which presented his interpretation of the results. This communication began with the aphorism, "Nothing is perfect at birth." Beijerinck then pointed out that "the most acceptable theory of heredity is the conception that the living part of the protoplasm of the cell [which he called the photoplasm in luminous bacteria] is built up of a great number of factors or bearers, different from one another, which determine the characters of the organism. . . ." He then wrote: "The fundamental conception here to be proposed [is] that every hereditary character of an organism corresponds to one or more enzymes which exert a reaction on specific substrates." Beijerinck held that no character was better suited to study "the process of mutability" than the "phosphorescence" of bacteria, and referred to the existence of luciferin and luciferase in luminous organisms. His viewpoint was very definitely modern.

All workers with luminous bacteria have noted the dim and dark mutants which Beijerinck described, and a number of persons have made use of them in genetic studies. Gerretsen (1915, 1920), Doudoroff (1938), Giese (1943), McElroy and Farghaly (1948), Miller, Farghaly, and McElroy (1949), McElroy and Friedman (1951), and Rogers and McElroy (1955) have continued the work.

A most important investigation was carried out by Doudoroff (1938), who endeavored to find out what constituent of the culture medium was responsible for the loss of luminescence. He discovered that with some of his dim strains, but not with all, the addition of "lactoflavin" to the culture-medium would restore the intensity of luminescence, and he concluded that flavin or a derivative of flavin was connected with one of the enzymes involved in the production of light by the bacteria.

Giese (1943) described the converse of a dark mutant, a "brilliant variant," which appeared when the medium was allowed to become acid, although the new variant would grow on calcium carbonate-buffered agar. This mutant developed a yellow pigment, which diffused into the medium and would fluoresce in ultraviolet light, that suggested riboflavin. The recent knowledge of luminous bacterial chemistry, as previously indicated, has made this observation, as well as that of Doudoroff, particularly significant. Certain dim mutants have their luminescence increased by riboflavin and certain particularly bright mutants produce an excess of what appears to be a flavin.

Probably the most interesting mutant has recently been described by Rogers and McElroy (1955). It is one which contains all the essential substances for luminescence except the long-chain aldehyde. Rogers and McElroy found that addition of minute amounts of dodecaldehyde to colonies of this dark mutant immediately restored the light. They also proved that the dark aldehydeless mutants contained bacterial luciferase which could be extracted and would act in vitro in the absence of bacterial cells, provided long-chain aldehyde, FMN, and DPNH (diphosphopyridine nucleotide, whose function is to reduce the FMN) were present. Presumably an aldehyde-forming or aldehyde-releasing enzyme is lacking in this particular mutant.

These authors also observed other dark mutants, which could not be made to luminesce by addition of FMN, DPNH, or long-chain aldehyde, i.e., by any of the cofactors involved in bacterial luminescence. Rogers and McElroy suggest that in such a case luciferase may be blocked or lacking. As a result of the above studies, luminous bacterial mutants lacking luciferin, or aldehyde, or luciferase are now available.

Since the ability to luminesce has appeared in bacteria of several different morphological types (rod-shaped forms, cocci, and vibrios), involving chemical systems of widespread occurrence in living cells (flavin mononucleotide, flavoprotein enzymes, and aldehydes), might not a luminous mutant suddenly appear in a well-known and much-studied form such as *Escherichia coli*? If phage-resistant or antibiotic-resistant mutants are found in nature, why not luminous mutants of common species also? Perhaps the innumerable strains of luminous bacteria which have been described are actually luminous mutants of certain species which normally are non-luminous. The possibility has not been properly tested. It would be worth while to find out if the non-luminous saprophytic bacteria which can be isolated from the skin of marine fish really represent the "normal" bacterium. They are discarded because the investigator has set out to isolate the more striking luminous mutant. Certain it is that the luminous

Vibrio albensis, obtained from the Elbe River by Sonnenschein (1931), is very closely allied to the cholera *Vibrio*, with similar immunological reactions and similar relations to attack by bacteriophage. Perhaps the goal of the investigator in this field should be the development of a luminous strain of yeast, or a luminous amoeba.

Thus the origin of luminescence in simple cells like bacteria is no different from the origin of other characteristics, for example, colors or fluorescent substances. Just as a slight change in the molecule can result in the formation of a brilliant pigment, so a similar change can produce a chemiluminescent compound. The living cell has many possibilities to choose from, as indicated by Fig. 1, which shows the wide variety of structural make-up among organic chemiluminescent compounds.

A concrete case in which a very slight change in a molecule is found to bestow the ability to chemiluminesce occurs among the phenylcyclohydrazides (or phthalic hydrazides), studied by Drew and coworkers (1939). In these compounds the presence of various groups in different positions greatly influences the intensity of the luminescence when catalysed by hemin or other organic metal-containing compounds. Such catalysts can be compared to luciferase. For example, aminophthalic hydrazide, with a methyl group substituted in place of one hydrogen of an NH group, would be non-chemiluminescent with hemin and hydrogen peroxide, but when the methyl group is removed, the hydrogen-containing aminophthalic hydrazide becomes brilliantly luminescent. If such a compound were present in the organism, a demethylating enzyme (gene) would result in a luminous mutant.

Removal of the amino group makes aminophthalic hydrazide much less chemiluminescent. The appearance of a deaminase in an organism might result in a dim mutant. It is by such small changes as this that the first beginnings of luminescence in a cell must have occurred.

Non-luminous varieties are also found in more complicated organisms. Among the higher fungi, *Panus stipticus* of Europe is non-luminous but the American variety, *P. stipticus luminescens*, emits light from parts of the fruiting body and the hyphae after they have grown a certain amount. Other fungi, for example, *Mycena galopus* and *Mycena polygramma*, observed by Bothe (1935), exist in two varieties. Macrae (1937, 1942) has made extensive genetic studies of the luminous and non-luminous *Panus stipticus* strains, and finds that they are completely interfertile. Diploid mycelia and fruit bodies of the F_1 generation are always luminous. Studies on the haploid mycelia from an F_1 fruit body indicate that "emission of light is governed by a single pair of Mendelian factors in which luminosity is dominant over non-luminosity and that the luminosity factors form all possible combinations with the infertility factors."

In the animal kingdom also, one species may be luminous and a closely allied species not. The earthworm, *Eisenia montana*, is luminous while *Eisenia foetida* is not. Some species of the dinoflagellate *Ceratium* are luminous, others not; while the famous *Noctiluca*, popularly regarded as the universal cause of "phosphorescence of the sea," may exist in a non-luminous condition.

Similar examples could be multiplied many times. They indicate how the ability to luminesce could have appeared at various periods of evolution and in widely separated phyla of the animal kingdom. The "first beginnings" of luminosity by mutation therefore present no problem, but it must be admitted that the factors involved in the change of a luminous spot to a complicated lantern are far from clear.

One of the early steps in the evolution of bioluminescence has been the development of a mechanism for controlling the light. Control of functional activity is found throughout the animal kingdom (with a few exceptions), and is usually mediated by nerves. In most of the Metazoa, a reflex stimulation of light-production is the rule, for example, in the flash of the fire-fly. Mechanical stimulation is usually sufficient to initiate the reflex, but in some fish, such as *Porichthys* (Greene and Greene, 1924), *Echiostoma* (Harvey, 1931), and *Argyropelecus* (Bertelsen and Grontved, 1949), light does not readily appear even upon strong mechanical stimulation. However, every photophore becomes brilliantly luminous if a little adrenaline is injected into the fish. Nicol (1955) has presented evidence that the adrenal gland of *Porichthys* is not involved in normal light-production, but that the nerves controlling the photophores are adrenergic.

In Protozoa also, light appears only upon stimulation. The slightest agitation of *Noctiluca* is sufficient to elicit a flash. Successive flashes fatigue the organism, and deleterious substances or conditions result in a "death-glow," the constant emission of a weak light.

The response of *Noctiluca* and other luminous flagellates is a typical "stimulus reaction," quite comparable to stimulation of a nerve or muscle cell. The question arises whether electrical phe-

nomena accompany the flash of light. Action potentials have been described during the luminescence of Metazoa (Hasama, 1943), but the origin of these potentials is not certain. In the case of *Noctiluca*, Hisada (1957) has observed an action potential accompanying tentacle movement, but was not sure of a potential change during luminescence.

The ability to respond to stimuli is one of the characteristics of living things which appeared early in the course of evolution, almost as soon as the aggregation of large molecules to form a cell. The evolution of "stimulus reactions" has not been sufficiently discussed, so intent has the evolutionist been on morphological characteristics, but it is certainly true that response to stimuli by luminescence is found as far down in the evolutionary scale as response to stimuli by movement of one kind or another.

THE EVOLUTION OF THE LANTERN-LIKE LUMINOUS ORGAN

In attempting to explain the evolution of complicated lanterns for producing light, a problem which I do not pretend to solve, it is necessary to present some of the facts regarding luminous animals which have a bearing on evolution. Then one or another of the various evolutionary theories may be found to fit the facts. The situation is quite comparable to the evolution of a cephalopod or vertebrate eye from a photosensitive spot. Important facts regarding luminous animals are as follows:

First, there are two types of luminescence. Light may come from a reaction wholly within the cell, as in luminous bacteria, flagellates, or the fire-fly—intracellular luminescence; or the chemiluminescent materials may be secreted to the exterior—extracellular luminescence, as in *Cypridina*. It is the species with intracellular luminescence which have developed the most complicated light organs; for extracellular luminescence little more than chemiluminescent materials are necessary.

Second, animal light may be of any color, although usually of a bluish tint. In one glow-worm, the "railway worm" of South America, *Phrixothrix*, there are eleven pairs of greenish-yellow luminous spots on the segments of the body, and a bright red light on the head. In a deep-sea squid, *Lycoteuthis* (*Thaumatolampas*), *diadema*, observed by Carl Chum on the Valdivia expedition of 1899–1900, most of the 24 light-organs emitted a white light, but the middle one of a semicircle of five on the eyeball was ultramarine blue, and the two toward the front of the lower surface of the body were ruby red. In these cases two, or perhaps three, chemiluminescent materials have appeared in one animal.

Third, luminous aninals may be terrestrial or aquatic, with the great majority marine. There seems little doubt that the abundance of luminous forms in the deep sea is connected with a life in perpetual darkness and that the evolution of light-organs progressed simultaneously with or after migration of the animal to the depths, rather than as a primary evolution of light-organs preadapting the species to move into the dark regions. Practically all students of animal distribution believe that the deep-sea fauna, whether luminous or not, migrated from the surface, both by following the bottom over the continental shelf as it plunged into the abyss, or by a gradual moving downward of pelagic forms in the open ocean. A secondary migration upward of deep-bottom animals to form a bathypelagic fauna may have also occurred. Little is known of the hadal fauna inhabiting the deeps or trenches of the ocean (see Bruun, 1956).

Such an evolutionary migration can be visualized among fish of the order Pediculati, where shallow-water forms such as the angler-fish (*Lophius*), may live on the bottom, or be found at the surface of the high seas, like the gulfweed or sargassum fish (*Pterophryne*). It requires little imagination to visualize the transformation of the protectively colored gulfweed fish into a black deep-sea angler or devil-fish. Likewise, the fishing-frog or angler (*Lophius*) has the form of one of the deep-sea ogcocephalids, some of which are said to be luminous. Gregory and Conrad (1936) have traced the evolution of pediculate fishes, indicating how the various families may have branched from the Antennaridae, which had a common origin with the Batrachoididae (containing luminous species) and the Branchionichthyidae. The relationships are based chiefly on fin and skeletal characteristics. The fishing lure or illicium, whose tip (esca) may be luminous, is a modification of the first ray of the dorsal fin. For details of ceratioid history and structure the reader is referred to Waterman (1939, 1948) and Bertelsen (1951).

Conditions in the ocean depths are extraordinarily constant in various regions of the world. Not only is there constant darkness, but a constant uniform temperature slightly above the freezing point, a high hydrostatic pressure, almost no motion—eternal stillness—and a lack of food. The

stillness of the depths has resulted in the evolution of delicate tissues and long feelers which would be quickly broken off in the turbulence of the surface waters. The lack of food is indicated by the enormous jaws and distensible body, so that deep-sea fish can swallow animals larger than themselves, making sure that a meal, once gained, will last a long time.

In general, these constant conditions have resulted in a wide geographical distribution of deep-sea forms. The same species are found in oceans separated by continents, although subspecies may have a more limited distribution, as indicated particularly by Haffner's (1952) study of *Chauliodus*.

Fourth, freshwater luminous species are practically non-existent, despite the fact that large freshwater lakes exist deep enough for perpetual darkness near the bottom. Lake Tanganyika of central Africa is 4700 feet deep, and Russian Lake Baikal has a greatest depth of some 5000 feet. Both lakes are very uniform in temperature the year round below certain depths, but the water of Tanganyika lacks oxygen below 300 to 660 feet. In Lake Baikal the water is well oxygenated at all depths, but there has been no evolution of a deep-lake luminous fauna, although abyssal gammarids are large, with a poorly developed exoskeleton and long feelers (Brook, 1950).

The only true freshwater luminous animal is the limpet, *Latia neritoides*, living in streams and ponds of New Zealand. Its biology has been described by Bowden (1950). Perhaps aquatic fire-fly larvae, breathing through the skin (Annandale, 1900) or by a respiratory funnel (Annandale, 1906) or by tracheal gills (Blair, 1927; Okada, 1928), may be considered aquatic forms. Certain luminous bacteria also exist in fresh water.

The scarcity of luminous organisms in fresh water cannot be dismissed with the simple statement that salt is necessary for luminescence. *Cypridina* luciferin and luciferase will react and emit light in a test-tube in water devoid of all traces of salt. Moreover, there is always salt in the cells of any organism living in fresh water. It is really surprising to find that an aquatic limpet and an aquatic glow-worm larva are the only representatives of luminosity in fresh water anywhere, whereas terrestrial light-producers exist not only among beetles and snails, but also among collembola, hemiptera, diptera, chilopoda, diplopoda, and fungi. The remaining thirty-five odd groups of luminous organisms are all marine. It is not known why the freshwater fauna lacks luminous species.

Fifth, there are no luminous freshwater cave animals, and the only well-known cave-dwelling form which is luminous is the New Zealand glow-worm, *Arachnocampa* (*Bolitophila*) *luminosa*, the larva of a fly. The adult is not luminous. These larvae spin webs on the ceiling of a cave and their light is of definite value and of evolutionary significance, as has been pointed out by Goldschmidt (1948). Fly larvae of this type will be discussed shortly.

Sixth, no metazoan parasites are luminous, but parasitic luminous bacteria may occasionally infest a living animal and give rise to a luminous disease which is usually fatal. Such occurrences are known among sandfleas, midges, caterpillars, a freshwater shrimp, and other forms. However, by far the most extraordinary situation is to be found among animals which harbor luminous symbiotic bacteria. An early case among fishes was described by Osorio (1912), for *Malacocephalus*, and later cases by Harvey (1921, 1923) in the famous Indonesian surface fishes, *Photoblepharon* and *Anomalops*. When disturbed, *Malacocephalus* squeezes (by muscle contraction) the luminous bacteria from an internal gland-like cavity, whereas in *Photoblepharon* and *Anomalops*, the light-organ is a prominent structure under the eye, highly specialized for the growth of the bacteria, and equipped with devices for controlling the light. Many other fish are now known to emit light from symbiotic luminous bacteria. It is quite obvious that a fish may use a light-organ containing bacteria for the same purpose as a self-luminous organ. The bacteria, of course, gain nutrient from the fish. The mutual benefit to host and symbiont cannot be questioned.

At one time Pierantoni (1914) regarded the light of the fire-fly as bacterial in origin, and both he and Buchner (1914, 1953) have been inclined to consider the light of luminous animals in general to be due to symbiotic luminous bacteria. Such is certainly not the case, but among fishes, and possibly in certain squids, the symbiotic origin of the light is unquestionable.

With these general statements concerning light-producing organisms and their habitats, we may now turn to some of the more specific facts of interest for an understanding of the evolution of lantern-like light-organs. Is it possible to recognize a direct series of light-producing structures of greater and greater complexity?

In the deep-sea shrimps, squids, and fishes, light is usually emitted from "photophores" with lenses and reflectors, whose distribution over the body surface is characteristic of the species, and is frequently different in the male and the female. A crustacean photophore is shown in Fig. 2. The variety of structure in these light-organs does allow them to be arranged in a series from simple to complex, but it would be hazardous to claim that the more complicated light-organs are found in fish which have evolved from those with simpler light organs. The structure of the photophore has not been used as a family classification characteristic, nor is it possible to correlate complicated photophore structure with evolutionary lines of development. In fact, an individual fish may have many different types of light-organ, some of which are simple and some complex. The characters of fins and teeth have been generally used for classification of families; only when the problem of distinguishing species in a genus arises has the distribution of photophores been of major importance. The value of photophore pattern was especially recognized by A. Brauer (1905), who developed a system of nomenclature in connection with his study of the genus *Myctophum*. The photophores of *Porichthys* are illustrated in Fig. 3.

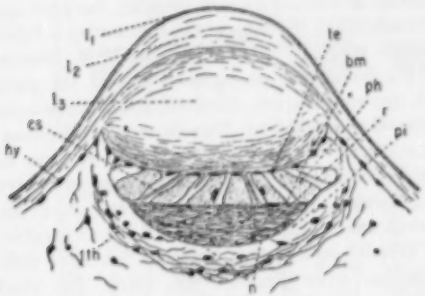

FIG. 2. SECTION OF A PHOTOPHORE OF THE SHRIMP *SERGESTES PREHENSILIS*

Lens (l_1, l_2, l_3), photogenic cells (ph), reflector (r), and pigment layer (pi). [From Terao, 1917.]

Although deep-sea fish, especially the Stomiatoidea and the Myctophoidea, offer excellent

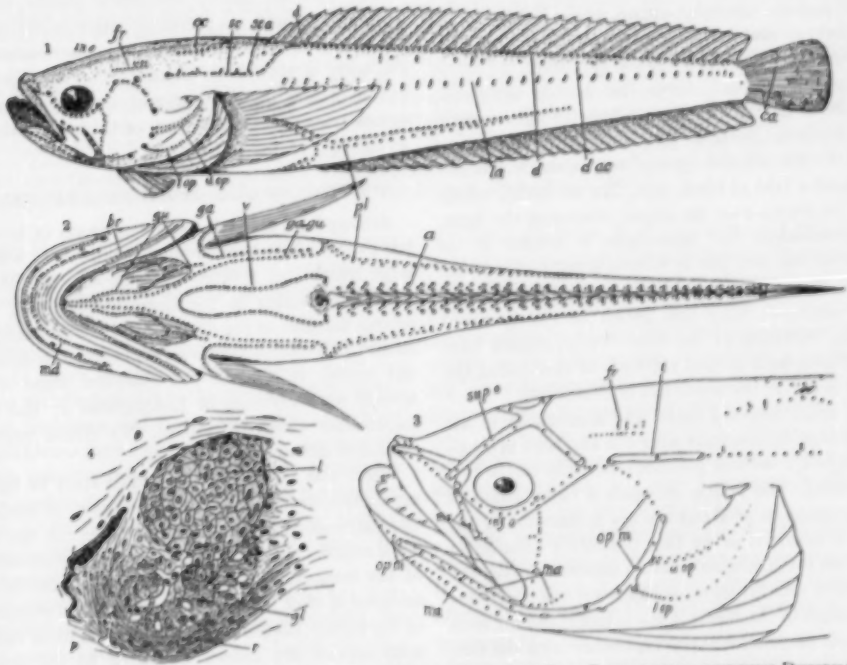

FIG. 3. DISTRIBUTION OF THE LIGHT-ORGANS OF A TYPICAL LUMINOUS FISH *PORICHTHYS*, SHOWING DESIGNATION OF PHOTOPHORES

[From Greene, 1899.]

material for speculation on evolutionary relationships, observation of these animals in the field is practically impossible, and a correlation of structural with ecological relationships cannot be made (see the discussion of Marshall, 1954). Why, for example, should so many deep-sea fishes possess a triangular cheek light-organ below and somewhat behind the eye? The author (Harvey, 1931) observed that this cheek organ in *Echiostoma ctenobarba* flashed rhythmically with a bluish luminescence when the freshly caught fish, kept in ice-cold sea water, was handled, while the principal lateral line of light-organs and the numerous minute light-organs embedded in the skin did not light up until adrenaline was injected into the fish. The light of the latter was yellowish, lasted some time, and then went out, while the cheek-organ continued to flash rhythmically during and after the adrenaline injection.

In the case of *Echiostoma*, the control of flashing was presumably by nerves ending on photogenic cells, since the surface of the cheek light-organ was bare, but among the surface fishes belonging to the Anomalopidae, *Photoblepharon* and *Anomalops* each possess subocular organs whose light may be turned on and off. However, the mechanism of control is quite different in the two fishes. As previously pointed out, these fish harbor symbiotic luminous bacteria in their subocular light-organs. All luminous bacteria emit light continuously, so that to cut off the light, *Photoblepharon* has developed a fold of black skin, like an eyelid, which can be drawn over the organ, obscuring the light. In *Anomalops* the light-organ is hinged at its anterior end and can be turned inward toward the body, thus presenting the black pigmented opaque side outward. Why two genera of closely allied fishes, belonging to the same family, should have developed such diverse methods of controlling the light is one of the mysteries of evolution.

In most deep-sea fishes and shrimps there are prominent light-organs near the eye, and in deep-sea squids, a favorite position is actually on the eyeball itself. The reason for such a distribution of light-organs on or about the eye is obscure. At one time it occurred to me that possibly a light-organ near the eye might serve as an indicator to tell the organism whether its other lights were on or off, but the design of the lights is too complicated for such a simple purpose, and my experience with the fish, *Echiostoma ctenobarba*, previously described, indicates that the control of the cheek light is quite distinct from that of body photophores. If the eyeball lights of squid are for recognition we might suppose that one individual approaches another, looks it squarely in the eye, and then decides by the pattern of eyeball lights whether its opponent is friend or foe.

Moreover, interpretation of eye-ball photophores is complicated by the fact that in some squid, notably *Histioteuthis* and *Calliteuthis*, the right eye is smaller than the left and the distribution of light-organs is quite different (Chun, 1903; Degner, 1923). Sometimes photophores around the giant left eye are far apart, distorted, and in some cases reduced to a rudiment. There is as yet no explanation of this unusual asymmetry in relation to habits or behavior. Perhaps light-organs on the eye are merely to assure that both eye and object observed are as near the source of light as possible. It is quite certain that luminous fish have well-developed eyes (Brauer, 1906, 1908). The blind forms are non-luminous. An interesting discussion of eye adaptations will be found in Walls (1942).

Another case of asymmetric luminous organs is to be found among the copepods. The light-producing cells are merely unicellular glands, sometimes paired, with no accessory lenses or reflectors. According to Giesbrecht (1895), the distribution on the body is always the same in any one species, but in a few the arrangement is not bilaterally symmetrical. The significance of this peculiarity is unknown.

EVOLUTION OF LIGHT-PRODUCING COLEOPTERA

Among land animals, only one group of beetles has evolved into light-producing organisms with a large number of species. The fire-flies and glow-worms, belonging in the Lampyridae and a few related families of the Cantharoidea or Malacodermata (with twelve families), are found throughout the world. E. Olivier has recorded some 1400 species and varieties of Lampyridae in the *Coleopterorum Catalogus* (1910). No doubt several thousand different species exist.

There was another evolutionary start in light-production among a second large group of beetles, the Elateroidea (containing eight families), but for some reason this branch did not attain the diversity of the lampyrids. At the present time the light-emission of click beetles is restricted to a few genera of the family Elateridae. About one hundred luminous species are known belonging to the genus *Pyrophorus*, from tropical and subtropical America. Two species of the genus *Photophorus* (said to be very similar to *Pyrophorus*) from the Fiji Islands

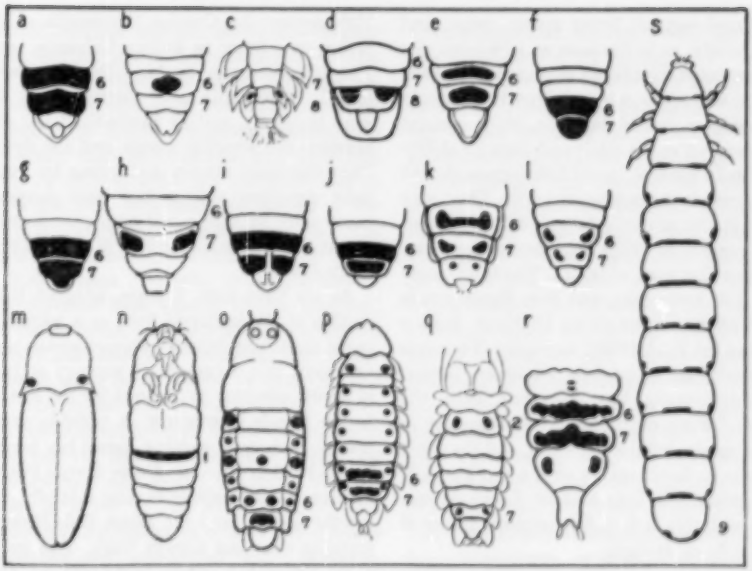

FIG. 4. OUTLINE DIAGRAMS SHOWING POSITIONS AND SIZES OF PHOTOGENIC ORGANS IN REPRESENTATIVE FIRE-FLIES

Photogenic organs indicated in solid black. Numbers refer to abdominal segments. Ventral views, unless otherwise noted. Sizes are variable and are not shown to scale, but normal size of *Phengodes* (s) is about 40 mm., of *Pyrophorus* 25 mm., and the entire "average" fire-fly 10 to 15 mm. a, *Photinus scintillans*, male; b, *Photinus scintillans*, female; c, *Photuris pennsylvanica*, larva; d, *Diphotus montanus*, male; e, *Photuris pennsylvanica*, female; f, *Luciola chinensis*, male; g, *Luciola cruciata*, male; h, *Luciola lusitanica*, female; i, *Luciola* sp., male; j, *Luciola lateralis*, male; k, *Pyrocoelia rufa*, female; l, *Leconteä lucifera*, female; m, *Pyrophorus noctilucus*, dorsal; n, *Pyrophorus noctilucus*, ventral; o, *Lamprorhiza* (*Lampyris*) *splendidula*, female (the number of lateral organs is quite variable); p, *Phausis mulsanti*, female (the number of lateral organs is variable); q, *Phausis delarouzeei*, nymph, dorsal; r, *Lampyris noctiluca*, female; s, *Phengodes* sp., dorsall Figures a, b, c, and e, after Hess. Figures f, g, i, j, k, and l, after Okada. Figures b, h, p, and q, after Bugnion. Figure o, from various sources. Figure r, after Bongardt. Figures d and s, after Buck. Figures m and n from Seaman. [From Buck, 1948.]

and the New Hebrides have been described, and one species of another genus, *Campylaxenus pyrothorax*, from Chili. This is the extent of luminescence among the elaterids.

Although elaterid lights may be brighter than those of most of the lampyrids, practically no species variation occurs in the position of the light-organs, and no sexual dimorphism. All individuals of *Pyrophorus* have two bright oval luminous spots on the posterior-lateral margin of the prothorax, and a ventral irregularly heart-shaped luminescent organ on the ventral side of the first abdominal segment, visible only when flying or when the elytra are expanded.

The opportunity to study their habits (as compared with the inaccessibility of deep-sea fish), the great number of species, their world-wide distribution, and the variety of lantern types make the Cantharoidea (Malacodermata) of particular value for study of evolution (Fig. 4). Structurally, the light-emitting tissue is of two sorts: (1) isolated, rather loose groups of light-producing cells with the form of oenocytes in the genus *Phengodes* (Phengodidae) and (2) compact masses of cells of mesodermic origin in *Phrixothrix* (Drilidae) and various genera of the Lampyridae. Sometimes a "reflecting" layer is present. If the tracheae which supply lampyrid lanterns terminate through tracheal end cells the insect is able to flash rapidly, but if tracheal end cells are absent, the light comes on, lasts some seconds, and then dies away slowly, as in the glow-worm (see Buck, 1948).

There is considerable variation in the size of wings, depending on the species or the sex, and frequently complete absence of wings occurs in the adult. Such a form is then called a glow-worm (for example the European glow-worm of song and story). The larval form of adult winged insects or fire-flies is also called a glow-worm.

Some lampyrids are luminous throughout life—

the unfertilized egg, all larval stages, pupa, and adult. Frequently, as in *Photinus* and *Photuris*, the adult light-organ is completely reformed during the pupal period and appears in a different position in the abdomen from that of the larva, which remains only as a remnant in the adult and loses its ability to emit light. In general, larval light-organs do not flash, since they lack tracheal end cells. They may also persist in the winged adult as the permanent adult light-organs, in which case the lighting characteristics are like those of larvae. The light comes on slowly, lasts some time, and then disappears in the winged adults of the genus *Diphotus*. Such a condition has led Buck (1942) to regard this genus as "a primitive forerunner of the *Photinus-Photuris* type . . . evolutionarily less advanced than the latter genera." Frequently the larval stage only in a particular species will be luminous, and the adult non-luminous, or luminous for only a short period, as in the genus *Ellychnia* and in *Lucidota atra*. Correlated with this lack of light-organs, adults of these species fly in daylight.

Sexual dimorphism among lampyrids is particularly characteristic of the light-organs and also as regards presence or absence of wings. If male and female are both winged, the male has larger light-organs, larger eyes, and greater activity. If the male is winged and the female apterous or with rudimentary wings, the female has the more conspicuous light-organs, and they may be lacking in the male whose eyes are nevertheless well developed. Occasionally both sexes may be apterous and luminous (*Phosphenus hemipterus*), or both sexes winged and non-luminous (*Alychnus*, now included in *Lucidota*), (See Olivier, 1908, 1909). Larvae are probably always luminous.

It is important to note that wing and luminescence characteristics may vary greatly within a single genus. For example, in *Photinus pyralis* both male and female are winged, with the female less brilliant, while in *Photinus scintillans* the female is apterous, with a longer (although less intense) flash than the male. Both species may be found in the same locality. While such characters are not related to the morphological characteristics (antennae and genitalia) used in classification, they are definitely related to habits, and of value in deciding the direction of evolution.

The evolution of light-organs among fire-flies and glow-worms is connected with reproduction. There can be no doubt that their light is used to attract the sexes and has a very definite selection value. Such a purpose was suggested in the early 17th century by Carolus Vintimiglia of Palermo, Sicily, in a letter to Fabius Columna, quoted by Thomas Bartholin in his "*De luce animalium*" (1647). Vintimiglia also observed that the eggs were luminous, and he emphasized the difference between the wingless female and the flying male. That the sexes attract each other by means of a light signalling system has been recognized by many since that time, and amply confirmed by the recent experimental studies of Mast (1912) and Buck (1937).

As we have seen, Darwin adopted Belt's suggestion of the lampyrid light as a warning signal, based on distastefulness to insectivorous mammals, and used this argument in support of his theory of sexual selection to account for the loss of wings in the female glow-worm. A possible case of the fire-fly flash as a warning signal has been related by Shelford in *A Naturalist in Borneo* (1916). Shelford saw a gecko about to seize a fire-fly, when the fire-fly flashed, and the gecko fled. However, the warning does not always work. The author was once astounded, while collecting in Cuba, to discover a luminous toad. Further investigation revealed that the toad had just finished a hearty meal of fire-flies whose light was shining through the toad's belly with considerable intensity.

Whenever a species is distasteful to predators mimicry by other species is an expected consequence, and the question arises whether well-authenticated cases of mimicry of fire-flies can be recognized. A. R. Wallace was, perhaps, a little enthusiastic when he held (*Tropical Nature and other Essays*, 1878, Chapter V) that luminous elaterids mimic lampyrids, "whose light, as originally suggested by Mr. Belt, is admitted to be a warning of its uneatability." Blair (1915) has held that the longicorn genera of beetles, *Amphionycha* and *Dadoychus*, resemble fire-flies, even to the possession of a ventral whitish patch like a lantern.

More recent accounts of insects which mimic fire-flies appear to be lacking, although the idea that light-emission by other luminous forms is a warning has been generally adopted. Poulton, in *The Colours of Animals* (1890, p. 201), referred to the bright red marine terebellid worm, *Polycirrus aurantiacus*, whose tentacles "possess some unpleasant attribute" and are "brilliantly phosphorescent," making them "conspicuous by night as well as by day." Poulton quoted Mr. Garstang, who had observed that fish would not touch the worm unless the tentacles were cut off, after which they ate it voraciously.

A possible converse case of a fire-fly (*Callopisma*) mimicking another insect (*Thonalmus*) is of some interest. The situation has been discussed by Darlington (1938), who made field studies in Cuba. The Cuban lycid beetle, *Thonalmus suavis*, is a striking insect, with head, thorax, and front half of the elytra yellow, while the posterior half of the elytra are blue. Non-luminous beetles of the Oedemeridae (*Copidita thonalmus*), of the Elateridae (*Anoplischius venustus*), and three genera (*Calozcosmus*, *Trichras*, and *Heterops*) of the Cerambycidae have exactly similar blue and yellow color areas, while certain luminous lampyrids (*Callopisma* sp.) "resemble *Thonalmus* in a general way, being yellow or orange, with antennae and apical half of elytra black." However, the resemblance between mimic and model is imperfect, and the fact that species of *Callopisma* are forest-dwellers and mostly nocturnal and are not likely to occur in the same habitat with *Thonalmus* led Darlington to believe the fire-flies "are probably not mimics at all." However, mimicry of *Thonalmus* was established for the other beetles.

The ability to luminesce can be considered an adaptation for living in the dark—in lampyrids a very beautiful adaptation for bringing the sexes together. Among deep-sea animals it would seem as if the complicated lantern is almost too perfect an adaptation. Something less complex would do just as well, if the true purpose of the light is for recognition. A row of luminous spots would function in the same way as a row of lanterns.

THE EVOLUTION OF LIGHT-PRODUCING DIPTERA

One can imagine how "an error in metabolism" might result in the appearance of a chemiluminescent compound closely allied to one of the "necessary metabolites." It is more difficult to conceive how an enzyme of the specific structure to catalyse the chemiluminescent substance with light-emission could have arisen. But the further evolution of a complicated light-organ lantern is somewhat baffling. Even though the light-emitting cells of an animal form no more than a spot of light, the problem of how the other physiological and anatomical characteristics, as well as the habits of the animal, combine to make the light of adaptive value, is a more difficult one. Goldschmidt (1948) has called attention to this aspect of evolution in the case of the New Zealand glow-worm, which has multiplied in enormous numbers in some caves of North Island and has become a tourist attraction. Hudson (1926) has summarized our knowledge of its biology.

The insects are larvae of a fly, *Arachnocampa luminosa*, belonging to the family Bolitophilidae, one of the group of fungus gnats. Most fungus gnats live on and eat fungi but a few, among them *Arachnocampa*, are carnivorous. The adults of *Arachnocampa* are not markedly luminous, but the larvae spin webs, from which hang glutinous threads, on the walls and roof of a cave or in dark ravines. These colonies are always near water, in which midges (a chironomid fly of the genus, *Tanysus*) hatch and fly up toward the light of the glow-worms, and become caught in the glutinous threads. The glow-worm then hauls in the threads by means of its specially formed mandibles and eats the midge. The light of the glow-worm comes from the enlarged ends of the four Malpighian excretory tubules (Wheeler and Williams, 1915) and it shines almost continuously. The light is only extinguished in bright light, at a low temperature, or after a sudden noise. How can such an adaptation have arisen, to transform part of an excretory organ (of all tissues) into a device to aid in obtaining food?

Goldschmidt has pointed out that the new adaptation of a carnivorous habit among normal fungus-eaters could not have developed without all of some eight acquisitions: "(1) the tendency of the larva to live in dark moist places; (2) the development of a continuously shining organ of luminescence out of Malpighian tubules; (3) the ability to build a tent; (4) the ability to build the trapping threads and to insert in them the special sticky droplets; (5) the carnivorous habit with all its physiological adjustments; (6) the ability to choose the proper habitat where the prey breeds in large numbers; (7) the instincts needed for the feeding process; (8) the adaptation of the entire life-cycle to the ecological features."

Goldschmidt asks how all the chance variations or slight mutations necessary for the above adaptation can have occurred simultaneously, since each one alone would have had no selection value. Fortunately, mycetophilid larvae have been much studied (see Schulze, 1924). A search for intermediate steps shows that some non-luminous fungus-gnat larvae avoid the light, and that some luminous ones form slimy webs on the under surfaces of fungi, but only to help retain the fungus moisture. One of these, *Ceroplatus sesioides*, belonging to the Platyuridae, is luminous from cells of the fat-body scattered among the viscera of

the larvae. The adults are luminous only for a day or two during the time that the fat body is being absorbed. However, *Ceroplatus* larvae differ from those of *Arachnocampa* in that they feed on fungus spores. The biology of *Ceroplatus* has been thoroughly studied by Stammer (1933), who concluded that luminous bacteria were not the source of the light. In a later paper, Goldschmidt (1951) called attention to the report of Enslin (1906), that *Macrocera fasciata* had caught a moth in its nest of slimy threads and might be carnivorous.

Study of the habits of various English fungus gnats by Madwar (1935, 1937) has revealed another species of *Ceroplatus*, *C. lineatus*, which eats fungus spores and spins sticky webs, but is non-luminous. The same is true for *Macrocera anglica* (Macroceridae), living under loose damp bark. *Polylepta leptogaster* (Sciophilidae) and *Sciara coprophila* (Sciaridae), with the same web-spinning habit, usually eat fungus spores, but may occasionally become carnivorous, devouring the dead bodies of adults of the same species (Madwar, 1935). According to Mansbridge (1933), *Macrocera stigma* has carnivorous habits also, but no mention is made of any luminosity. Schmitz (1912) and Cheetham (1920) have also studied *Polylepta leptogaster*.

Among American fungus gnats, Fulton (1939) has observed larvae of *Sciara* sp. (related to *S. jucunda*), which live gregariously in rotten wood, filling spaces in the wood with a network of coarse dry fibers. This species feeds on the rotten wood, not on insects. The web seems to have no function unless to exclude enemies from the crevice where the larvae feed. In addition, Fulton observed a species of web-forming *Ceroplatus*, whose larvae would occasionally attack an insect caught in the web, allowing it to die before eating it. None of the above species were luminous.

The most interesting American "fungus gnat" is quite comparable to the New Zealand glow-worm. This larva belongs in another genus of the Ceroplatidae, *Platyura*, and is a luminous species, *P. fultoni* of the Appalachian mountains. *Platyura* also spins branching glutinous webs in wet shaded places stretched across worm holes, or in the crevices between stones or in deep beds of moss, by which small insects are caught and eaten. Like *Arachnocampa* they are never associated with fungi. The food consists mostly of collembola. In order to catch them, the larva takes a position at night on the web at the entrance to the cavity, with light from the forepart of the body plainly showing.

According to Fulton (1939, 1941), the luminescence comes from rows of small black structures like loosely strung beads extending throughout the body. When dissected under water, light is not visible until the black bodies are broken open, when a luminous material spreads thrugh the water. The light from the intact larva seems to be diffuse throughout the body, and Fulton suggested that the black bodies might secrete luminous material. A histological study is much needed, to determine the nature of the luminous tissue.

Finally, Cook (1913) has described an unidentified "web spinning fly larva from Guatemalan caves," but no mention of luminescence was made. This form spins a horizontal cable, 1 to 2 feet long, suspended from the ceiling of the cave. From this cable a fringe of vertical shiny threads 2 to 3 inches long hangs down. The threads are a few millimeters apart, well suited to catching insects, while the larva lies on the horizontal cable ready to eat them.

These cases of change in food habit are described in some detail to indicate that in several different families there has appeared a tendency to a carnivorous diet; also that the type of web which is spun varies from a few dry threads to a most complicated device for catching insects. We may suppose that the spinning habit was first used in connection with protection of the pupa, i.e., for the formation of a cocoon, which is commonly foung among mycetophilid larvae. Light-emission has appeared in three genera (*Ceroplatus*, *Arachnocampa*, *Platyura*), in such widely separated regions as Europe, North America, and New Zealand. Perhaps the most extraordinary fact is the wholly different type of tissue from which the light is emitted—fat-body, Malpighian tubules, and bead-like structures of unknown character.

The New Zealand glow-worm is therefore not unique, and intermediate steps, i.e. incomplete adaptations, do exist. As in many other cases among animals, the question may be asked which appeared first in the course of evolution, the carnivorous habit or the morphological changes connected with insect-catching? Whatever the answer, it is hard to understand how there could be much selection value until the adaptation was fairly complete.

It should be noted that in these larvae there is no indication of evolution in a definite direction, such as the evolution of brighter and brighter Malpighian tubules. As in the case of the fishes, *Photoblepharon* and *Anomalops*, which have radically different mechanisms for controlling their

light, the great mystery connected with the dipterous larvae is why the luminescence should develop in such different types of tissue.

Goldschmidt has pointed out that the "Neo-Darwinian concept would require the accumulation of innumerable small and integrated mutants by selection, though none of them could individually have had any selection value"; also that "an accumulation and integration of all these steps without selection, merely by chance combination of neutral mutants, appears still more improbable." He finally concludes: "I cannot see any plausible explanation except by one or a few large mutational steps accomplishing quickly the entire integrated set of adaptive changes."

But do we not forget the time element? Perhaps, given sufficient time, the hereditary transmission of a useless together with a useful character did finally result in a combination of real value to the larva, the first step for selection. Addition of subsequent combinations might finally result in the perfect adaptation, involving both habit and structure.

When we realize that light-emission by fungus gnat larvae does not involve the development of a complicated light organ—a lantern—but is merely an aggregation of luminous cells, how much more difficult is it to visualize the evolution of the lighting systems of shrimp, squid, and fish? As Darwin remarked, it does seem "impossible to conceive how these wondrous organs have been produced." But is it not even more difficult to imagine the intermediate steps between an ancient trireme and the modern luxury liner? The evolution of speedy and comfortable transportation has been accomplished by human selection of the best adapted for a particular goal, and the process has taken mere centuries, rather than millions of years. With present-day knowledge, the beginnings of light-production by living things seems far from impossible, and the slow perfection of a "living lantern" is well within the capability of natural selection.

LIST OF LITERATURE

ANNANDALE, N. 1900. Observations on the habits and natural surroundings of insects made on the "Skeat Expedition" to the Malay Peninsula, 1899–1900. VI. Insect luminosity (an aquatic lampyrid larva). *Proc. zool. Soc. Lond.*, 1900, 862–865.

BEIJERINCK, M. W. 1889. Le photobacterium luminosum, bactérie lumineuse de la mer du nord. *Arch. néerl. Sci.*, 23: 401–415.

——. 1900. On different forms of hereditary variations of microbes. *Proc. Acad. Sci. Amst.*, 3: 352–365.

——. 1912. Mutation bei Microben. *Folia microbiol., Delft*, 1: 1–97 [esp. 49–54].

——. 1917. The enzyme theory of heredity. *Proc. Acad. Sci. Amst.*, 19: 1275–1289.

BERTELSEN, E. 1951. The ceratioid fishes. *Dana Rep.*, No. 39.

——, and J. GRØNTVED. 1949. The light organs of a bathypelagic fish *Argyropelecus olfersi* (Cuvier) photographed by its own light. *Vidensk. Medd. dansk naturh. Foren. Kbh.*, 111: 163–167.

BLAIR, K. G. 1915. Luminous insects. *Nature, Lond.*, 96: 411–415. [Also in *Proc. S. Lond. ent. nat. Hist. Soc.*, 1914–15: 31–45.]

——. 1927. An aquatic glowworm. *Nat. Hist. Mag.*, 1: 59. [Also in *Trans. R. ent. Soc. Lond.*, 75: 45–45.]

BOTHE, F. 1935. Genetische Untersuchungen über die Lichtentwicklung der Hutpilze I. *Arch. Protistenk.*, 85: 369–383.

BOWDEN B. J. 1950. Some observations on a luminescent freshwater limpet from New Zealand. *Biol. Bull., Woods Hole*, 99: 373–380.

BRAUER, A. 1905. Die Gattung *Myctophum*. *Zool. Anz.*, 28: 377–404.

——. 1906, 1908. Die Tiefseefische. *Wiss. Ergebn. 'Valdivia,' Jena*, I. Systematischer Teil., 15: Part 1 (1906). II. Anatomischer Teil., 15: Part 2 (1908).

BROOK, J. L. 1950. Speciation in ancient lakes. *Quart. Rev. Biol.*, 25: 30–60, 131–176.

BRUUN, A. F. 1956. The abyssal fauna: its ecology, distribution and origin. *Nature, Lond.*, 177: 1105–1108.

BUCHNER, P. 1914. Sind die Leuchtorgane Pilzorgane? *Zool. Anz.*, 45: 17–21.

——. 1953. *Endosymbiose*. pp. 61–66, 470–528. Verlag Birkhaüser, Basel und Stuttgart.

BUCK, J. B. 1937. Studies on the firefly. I. The effects of light and other agents on flashing in *Photinus pyralis* with special reference to periodicity and diurnal rhythm. *Physiol. Zool.*, 10: 45–58.

——. 1942. Problems in the distribution and light organ structure of Jamaican lampyrid fireflies. *Yearb. Amer. phil. Soc.*, 1942: 124–129.

——. 1948. The anatomy and physiology of the light organ in fireflies. *Ann. N. Y. Acad. Sci.*, 49: 397–482.

CHEETHAM, C. A. 1920. *Polylepta leptogaster*, Winn. A cave dwelling dipterous larva in Yorks. *Naturalist, Lond.*, 45: 189.

CHUN, C. 1903. Ueber Leuchtorgane und Augen von Tiefsee-Cephalopoden. *Verh. dtsch. zool. Ges.*, 13: 67–91.

COOK, O. F. 1913. Web spinning fly larvae in Guatamalan caves. *J. Wash. Acad. Sci.*, 3: 190–193.

CORMIER, M. J., J. R. TOTTER and H. H. ROSTORFER. 1956. Comparative studies on different bacterial luciferase preparations. *Arch. Biochem. Biophys.*, 63: 414–426.

DARLINGTON, P. J. JR. 1938. Experiments on mimicry in Cuba with suggestions for future study. *Trans. R. ent. Soc. Lond.*, 87: 681–696.

DEGNER, E. 1923. Zur Entwicklung von *Histioteuthis*. *Zool. Anz.*, 55: 215–220.

DOUDOROFF, M. 1938. Lactoflavin and bacterial luminescence. *Enzymologia*, 5: 239–243.

DREW, H. D. K. 1939. Chemiluminescence in the oxidation of certain organic substances. *Trans. Faraday Soc.*, 35: 207–216.

DUBOIS, R. 1887. Fonction photogénique chez le *Pholas dactylus*. *C. R. Acad. Sci. Paris*, 105: 690–692.

ENSLIN, E. 1906. Die Lebensweise der Larve von *Macrocera fasciata* Meig. *Allg. Z. wiss. Insektenbiol.*, 2: 251–253.

FULTON, B. B. 1939. Lochetic luminous dipterous larvae. *J. Elisha Mitchell sci. Soc.*, 55: 289–293.

——. 1941. A luminous fly-larva with spider traits (Diptera, Mycetophilidae). *Ann. ent. Soc. Amer.*, 34: 289–302.

GERRETSEN, F. C. 1915. Die Einwirkung des ultravioletten Lichtes auf die Leuchtbakterien. *Zbl. Bakt.*, Abt. 2, 44: 660–661.

——. 1920. Uber die Ursachen des Leuchtens der Leuchtbakterien. *Zbl. Bakt., Abt. 2*, 52: 353–373.

GIESBRECHT, W. 1895. Ueber das Leuchten der pelagischen Copepoden und das tierische Leuchten im allgemeinen. *Mitt. zool. Sta. Neapel*, 11: 631–694.

GIESE, A. C. 1943. Studies on the nutrition of dim and bright variants of a species of luminous bacteria. *J. Bact.*, 46: 323–331.

GOLDSCHMIDT, R. B. 1948. Glow-worms and evaluation. *Rev. sci., Paris*, 86: 607–612.

——. 1951. Eine weitere Bemerkung über "Gluhwürmer und Evolution." *Naturwissenschaften*, 38: 437–438.

GREEN, A., and W. D. MCELROY. 1956. Crystalline firefly luciferase. *Biochim. et Biophys. Acta*, 20: 170–176.

GREENE, C. W., and H. H. GREENE. 1924. Phosphorescence of *Porichthys notatus*, the California Singing Fish. *Amer. J. Physiol.*, 70: 500–507.

GREGORY, W. K., and G. M. CONRAD. 1936. Evolution of the pediculate fishes. *Amer. Nat.*, 70: 193–208.

HAFFNER, R. E. 1952. Zoogeography of the bathypelagic fish, *Chauliodus*. *System. Zool.*, 1: 112–113.

HARVEY, E. N. 1918. Studies on bioluminescence. VII. Reversibility of the photogenic reaction in *Cypridina*. *J. gen. Physiol.*, 1: 133–145.

——. 1921. Animal Light. *Trans. Illum. Engng. Soc.*, 16: 319–330.

——. 1923. The production of light by the fishes, *Photoblepharon* and *Anomalops*. *Publ. Carneg. Instn.*, 312: 43–60. [Also in *Science*, 53: 314–315.]

——. 1926. Additional data on the specificity of luciferin and luciferase, together with a general survey of this reaction. *Am. J. Physiol.*, 77: 548–554.

——. 1931. Stimulation by adrenalin of the luminescence of deepsea fish. *Zoologica, N. Y.*, 12: 67–69.

——. 1932. The evolution of bioluminescence and its relation to cell respiration. *Proc. Amer. phil. Soc.*, 71: 135–141.

——. 1952. *Bioluminescence*. Academic Press, New York.

——. 1953. Bioluminescence: evolution and comparative biochemistry. *Fed. Proc.*, 12: 597–606.

——. 1955. Survey of luminous organisms. In *The Luminescence of Biological Systems*. (F. H. Johnson, ed.), pp. 1–24. A.A.A.S., Washington, D. C.

HASAMA, B. 1943. Über die Bioluminescenz des *Plocamophorus tilesii* Bergh sowie der *Cavernularia haberi* Moroff im Aktionstrom sowie im histologischen Bild. *Cytologia*, 13: 146–154.

HASTINGS, J. W., and W. D. MCELROY. 1955. Purification and properties of bacterial luciferase. In *The Luminescence of Biological Systems* (F. H. Johnson, ed.), pp. 257–264. A.A.A.S., Washington, D. C.

HISADA, M. 1957. Membrane resting and action potentials from a protozoan, *Noctiluca scintillans*. *J. cell. comp. Physiol.*, in press.

HUDSON, G. V. 1926. The New Zealand Glow-worm, *Boletophila* (*Arachnocampa*) *luminosa;* summary of observations. *Ann. Mag. nat. Hist.* (Ser. 9) 17: 228–235; 18: 667–670.

KOMAREK, J., and K. WENIG. 1938. Die Eigenschaften des Leuchtens der *Eisenia submontana* Vejd. (Vermes-Olig.) und die Bedeutung der Bioluminescenz im Tierreich. *Věstn. čsl. Společ. nauk.*, (article 12), 1–12.

MACRAE, R. 1937. Interfertility phenomena of the American and European forms of *Panus stipticus* (Bull.) Fries. *Nature, Lond.*, 139: 674.

——. 1942. Infertility studies and inheritance of luminosity in *Panus stipticus*. *Canad. J. Res.*, 20: 411–434.

MADWAR, S. 1935. The biology and morphology of the immature stages of *Macrocera anglica*. *Psyche*, 42: 25–34.

——. 1937. Biology and morphology of the immature stages of Mycetophilidae (Diptera, Nematocera). *Phil. Trans.*, B, 227: 1–110.

MANSBRIDGE, G. H. 1933. On the biology of some Ceroplatinae and Macrocerinae. *Trans. R ent. Soc. Lond.*, 81: 75–92.

MARSHALL, N. B. 1954. *Aspects of Deep Sea Biology*. Pp. 262–298. Philosophical Library, New York.

MASON, H. S. 1952. The beta-luciferin of *Cypridina*. *J. Amer. Chem. Soc.*, 74: 4727.

MAST, S. O. 1912. Behavior of fire-flies (*Photinus pyralis*) with special reference to the problem of orientation. *J. Anim. Behav.*, 2: 256–272. [Also in *Science*, 35: 460.]

MCELROY, W. D., and A. H. FARGHALY. 1948. Biochemical mutants affecting the growth and light production in luminous bacteria. *Arch. Biochem.*, 17: 379–390.

——, and S. FRIEDMAN. 1951. Gene recombination in luminous bacteria. *J. Bact.*, 62: 129–130.

——, and A. GREEN. 1955. Enzymic properties of bacterial luciferase. *Arch. Biochem. Biophys.*, 56: 240–255.

——, and ——. 1956. *The enzymatic basis of light emission*. In *Enzymes, Units of Biological Structure and Function*. (O. H. Gaebler, ed.), pp. 369–380, with discussion pp. 381–389. Academic Press, New York.

——, and J. W. HASTINGS. 1955. Biochemistry of firefly luminescence. In *The Luminescence of Biological Systems* (F. H. Johnson, ed.), pp. 161–198. A.A.A.S., Washington, D. C.

MILLER, H., A. H. FARGHALY, and W. D. MCELROY. 1949. Factors influencing the recovery of biochemical mutants in luminous bacteria. *J. Bact.*, 57: 595–602.

NICOL, J. A. C. 1955. Physiological control of luminescence in animals. In *The Luminescence of Biological Systems* (F. H. Johnson, ed.), pp. 299–322. A.A.A.S., Washington, D. C.

OKADA, Y. K. 1928. Two Japanese aquatic glow-worms. *Trans. R. ent. Soc. Lond.*, 76: 101–108.

OLIVIER, E. 1908. Sur l'organisation des lampyrides. *C.R. Ass. franç. Av. Sci. (Clermont-Ferrand)*, 37: 573–580.

——. 1909. Distribution géographiques des lampyrides. *C.R. Ass. franç. Av. Sci. (Lille)*, 38: 669–671.

OSORIO, B. 1912. Une propriété singulière d'une bactérie phosphorescente. *C. R. Soc. Biol., Paris*, 72: 432–433.

PIERANTONI, U. 1914. La luce degli insetti luminosi e la simbiosi ereditaria. *R. C. Accad. Napoli*, 20: 15–21.

RADZISZEWSKY, B. 1877. Untersuchungen über Hydrobenzamid, Amarin und Lophin. *Ber. dtsch. chem. Ges.*, 10: 70–75, 321–322.

——. 1880. Über die Phosphorescenz der organischen und organisierten Körper. *Liebigs Ann.*, 203: 305–336.

——. 1883. Zur Theorie der Phosphoreszenzerscheinungen. *Ber. dtsch. chem. Ges.*, 16: 597–601.

ROGERS, P., and W. D. MCELROY. 1955. Biochemical characteristics of aldehyde and luciferase mutants of luminous bacteria. *Proc. Natl. Acad. Sci. Wash.*, 41: 67–70.

SCHMITZ, H. 1912. Biologisch-Anatomisch Untersuchungen an einer höhenbewohnenden Mycetophiliden larve, *Polylepta leptogaster* Winn. *Jaarb. natuurh. Genoot. Limburg*.

SCHULZE, R. 1924. Über Mycetophilidenlarven. *Zool. Jb. (Sys. Abt.)*, 48: 433–462.

SCOTT-MONCRIEFF, R. 1936. A biochemical survey of some Mendelian factors for flower colour. *J. Genet.*, 32: 117–170.

SONNENSCHEIN, C. 1932. Auf Leuchtvibrionen wirksame Bakteriophage. *Zbl. Bakt.*, Abt. 1, 126: 297–302. [Also 123: 92–93, 1931.]

STAMMER, H. J. 1933. Zur Biologie und Anatomie der leuchtenden Pilzmückenlarve von *Ceroplatus testaceus*, Daln (Diptera, Fungivoridae). *Z. Morph. Oekol. Tiere*, 26: 135–146.

STREHLER, B. L., and M. J. CORMIER. 1953. Factors affecting the luminescence of the cell-free extracts of the luminous bacterium, *Achromobacter fischeri*. *Arch. Biochem. Biophys.*, 47: 16–33. [See also *J. Amer. Chem. Soc.*, 75: 1264.]

——. 1955. Firefly luciferin. In *The Luminescence of Biological Systems* (F. H. Johnson, ed.), pp. 199–208. A.A.A.S., Washington, D. C.

STREHLER, B. L., E. N. HARVEY, J. J. CHANG, and M. J. CORMIER. 1954. The luminescent oxidation of reduced riboflavin or reduced riboflavin phosphate in the bacterial luciferin-luciferase reaction. *Proc. nat. Acad. Sci. Wash.*, 40: 10–12.

TOTTER, J. R., and M. J. CORMIER. 1955. The relation of bacterial luciferase to alternative pathways of dihydroflavine mononucleotide oxidation. *J. biol. Chem.*, 216: 801–811.

TSUJI, F. I. 1955. The absorption spectrum of reduced and oxidized *Cypridina* luciferin, isolated by a new method. *Arch. Biochem. Biophys.*, 59: 452–464.

TSUJI, F. I., A. M. CHASE, and E. N. HARVEY. 1955. Recent studies on the chemistry of *Cypridina* luciferin. In *The Luminescence of Biological Systems* (F. H. Johnson, ed.), pp. 127–160. A.A.A.S., Washington, D. C.

WALLS, G. L. 1942. The vertebrate eye and its adaptive radiation. *Bull. Cranbrook Inst. Sci.*, 19: 396–403.

WATERMAN, T. H. 1939. Studies on deep sea angler fishes (Ceratoidea). I. An historical survey of our present state of knowledge. II. Three new species. *Bull. Mus. comp. Zool. Harv.*, 85: 65–94.

——. 1948. III. The comparative anatomy of *Gigantactis longicirra* Waterman. *J. Morph.*, 82: 81–150.

WENIG, K., and V. KUBISTA. 1949. The presence of riboflavin in the luminous material of the earthworm *Eisenia submontana*. *Experientia*, 5: 73.

WHEELER, W. M., and F. X. WILLIAMS. 1915. The luminous organ of the New Zealand glow-worm. *Psyche, Camb., Mass.*, 22: 36–43.

NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will occasionally appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to H. B. Glass, Associate Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland, U. S. A.*

REVIEWS AND BRIEF NOTICES

General Biology: Philosophy and Education 288
Biology: History and Biography 291
The Young Naturalist 294
Ecology and Natural History 294
Evolution 297
Genetics and Cytology 300
General and Systematic Botany 304
Economic Botany 305
Plant Physiology 306
General and Systematic Zoology 306
Economic Zoology 311
Animal Morphology 311
Animal Growth and Development 312
Animal Physiology 315
Biophysics and General Physiology 319
Biochemistry 321
Microbiology 327
Parasitology 331
Health and Disease 331
Psychology and Animal Behavior 339
Human Biology 341
Biometry 345
De Omnibus Rebus et Quibusdam Aliis 348

GENERAL BIOLOGY: PHILOSOPHY AND EDUCATION

DIE SELBSTGESTALTUNG DES LEBENDIGEN. *Synoptische Theorie des Lebens als ein Beitrag zu den philosophischen Grundlagen der Naturwissenschaft.*

By Karl Friederichs. Ernst Reinhardt Verlag, München and Basel. Sw. fr. 20.20 (cloth); 17.80 (paper). 222 pp.; ill. 1954.

Modern *Naturphilosophie*, like its older counterpart, deplores the fact that science proper is limited to processes of analysis, and it endeavors to redress the balance by developing synthetic systems of thought on the philosophical side. *Die Selbstgestaltung des Lebendigen* attempts to effect such a synthesis on the basis of what its author calls autotelism. This is, in brief, an explanatory system which emphasizes *Geist* as primary in the living rather than as a mere attribute of living organization; it purports to bridge the great gaps between soul and body and between whole and part.

Granted that analysis of the whole, whether living or nonliving, into its parts is inadequate to serve as ultimate explanation of wholeness, there are many who believe that it remains a matter of opinion and not of fact whether the teleological explanation is completely satisfactory as a synthesizing system of thought. Non-teleologists seem often to feel that it is only a matter of free option, that no decision can be made on a strictly scientific basis, and that every individual must remain at liberty to choose his own position with respect to the teleological fence. The teleologists, on the other hand, seem, at least to the non-teleologists, less open-minded, and more convinced that they not only know, but must loudly profess, the Real Truth. The present author is no exception.

Although a zoologist (if sometimes a credulous one), he speaks with more authoritarian a tone than is expected of a man of science. Tightly packed as his argument is, both with biological fact and philosophical opinion, it loses some of its effectiveness by protesting too contentiously in justification of the teleological and metaphysical approach. The book is repetitious; and its style is most complicated and difficult to follow. It is more likely to be popular among professional philosophers than among the great majority of working biologists.

JANE OPPENHEIMER

CAUSALITÉS ET ACCIDENTS DE LA DÉCOUVERTE SCIENTIFIQUE. *Illustration de Quelques Étapes Caractéristiques de l'Évolution des Sciences.*

By R. Taton. Masson & Cie., Paris. 980 fr. (paper). 171 pp. + 32 pl.; text ill. 1955.

Causalités et Accidents de la Découverte Scientifique is one of a series of original monographs entitled *Évolution des*

Sciences:—Liaisons et Synthèses—Methodes et Techniques, addressed to a scientific audience and dealing with the essential nature of scientific research. This particular member of the collection, contributed by a mathematician, discusses the development of scientific concepts by considering the psychological processes of the individual investigator as a function of his moment in scientific history.

It is broad in its scope, in so far as it has chosen its examples from diverse fields: mathematics, astronomy, physics, chemistry, biology, and medicine. There is however a strong undertone throughout of emphasis on the more technological aspects of science. For instance, a subsection, *The problem of precursors*, of a larger section on *Originality of discovery* devotes slightly less than two pages to paludism; two to musical timber; a little over three pages to the prehistory of antibiotics; and eleven to a detailed and most fascinating description of the invention and development of lighter-than-air flying apparatus. The examples chosen from biology, throughout the volume, bear further witness to this tendency. The discovery of the circulation of the blood and the development of the evolution concept are barely mentioned (as examples of what the author considers revolutionary discoveries accepted only after considerable controversy). While three pages are devoted to the laws of Mendel as instances of forgotten discoveries, and one to Spallanzani's discovery of the role of the spermatozoa as an example of a *découverte manquée*, by far the greater part of the author's attention to matters biological is concentrated on the discovery of the antibiotics and on strictly medical discoveries concerned rather with improving methods of combat against disease than in elucidating more theoretical scientific principles.

From the specifically historical point of view Taton limits himself on the whole to tracing the interrelationships of ideas which are rather intimately related to one another, within the bounds of a single or of closely related sciences; he turns less attention to the relations of the various sciences to one another and to other disciplines of thought.

It is a strength of his volume, however, that it is original in its arrangement and organization. The material is presented in other than chronological sequence, and the historical data are included as subsidiary to the treatment of generalized problems which characterize many historical periods: the factors responsible for the fate of discoveries, unrecognized as such and made before their time; the function of chance, and of error, in scientific discovery; the place of logic and intuition in scientific method. The author is distinctly at his best when he considers, as he does in the bulk of his book, the creative thought processes of individual contributors. In fact, he has a number of original suggestions relating to these. Among them may be mentioned his interest in the significance of an aesthetic sense in directing mathematical discovery, and in the importance, in a number of discoveries, of the confluence of two currents of thought within the mind of a single investigator. These portions of the book, in particular, should prove of consummate interest to those who are concerned with psychological factors involved in the production of scientific creativity. The writing throughout is very good, and the pictorial illustrations are excellent.

JANE OPPENHEIMER

THE APPLICATION OF RESULTS OF RESEARCH. *British Commonwealth Scientific Conference.*

Compiled and edited by Vera Connell in collaboration with the British Commonwealth Scientific Offices (London). Academic Press, New York; Butterworths Scientific Publications, London. $5.00. viii + 212 pp. 1954.

This volume concerns itself with the methods by which the results of research are gotten into the hands of those who can apply these results to the advancement of industry, agriculture and, in general, human welfare. As a British report, it deals with affairs within the Commonwealth, but the ideas and methods involved are of concern to all who would utilize basic information for material and social progress. Few generalizations can be made, but in a competitive society effective liaison is necessary through publication, extension services, and intelligent personnel who can appreciate the need for basic information on the one hand, and can visualize its applicability to particular problems on the other. Such persons are understandably hard to find in any society.

THE CHANCE CHARACTER OF HUMAN EXISTENCE.

By John Brill. Philosophical Library, New York. $3.75. viii + 150 pp. 1956.

The theme of this book is that all phenomena, including man's every act and existence, are based on chance. The Darwinian theory of evolution relies upon chance genetic combinations and MAX PLANCK's quantum theory indicates that the movement of an individual electron is unpredictable. Therefore, the author argues, as electrons are the elementary particles of all matter, all phenomena are chance phenomena and for practical purposes never alike.

This idea is reiterated in every chapter of the book. On the basis of this theme, the author belittles and derides most of existing philosophy, theology, sociology, culture, and even politics. He states that all but his point of view is "befuddled by incorrect thinking" and that "practically without exception all the assumptions and conclusions in these fields suffer from the illusion that mind rather than chance is responsible for knowledge and human progress."

Some of the concepts to which Brill subscribes might be worthy of discussion, but as presented in his book, they are confused by contradictions and weakened by

sweeping, all-embracing generalities and conclusions based upon limited facts and questionable logic. To give but two examples:

The author has apparently no difficulty in reconciling his belief (based upon *one* experiment in physics) that "natural phenomena are not governed by law and are therefore subject to chance," with his repeated adherence to "the laws of nature," "instinctive decisions," etc.

Representative of Brill's logic is the following: "From an evolutionary point of view the brain or mind is a physical organism and as such is completely incapable of understanding anything that is non-physical. The non-physical is non-existent. Where there is nothing there is a vacuum which is the absence of anything. It is upon this premise that we rule out all consideration of spiritual forces upon which all religions are fundamentally based." Only the Q.E.D. seems to be missing here. But that may be in deference to those in the field of philosophy who, using a part of this same argument, have attempted to prove just the opposite!

The book as a whole reveals the author as a non-Marxian materialist, beset with a chronic persecution complex (possibly well-founded) and a militant spirit. At one point he states that "it is possible for the human to conceive nonsense." Some parts of his own book bear a silent witness to *this* theme.

CLAUDE F. BAXTER

THE LANGUAGE OF TAXONOMY. *An Application of Symbolic Logic to the Study of Classificatory Systems. By John R. Gregg. Columbia University Press, New York.* $2.50. xii + 70 pp. 1954.

This is an excellent book of its kind, but it is difficult to see what interest it would have for a biologist. It deals with straight mathematical logic, and not even the parts relating to taxonomy are required reading for non-logicians. The chapter on hierarchies is fine, but it reproduces work done elsewhere. The whole point of the book seems to revolve around the question of whether the notion of classes of classes—sets of sets—can be symbolized mathematically. Apparently they can.

CHARLES DARWIN AND THE GOLDEN RULE. *By William Emerson Ritter; compiled and edited by Edna Watson Bailey. Science Service, Washington; Storm Publishers, New York.* $5.00. xxii + 400 pp. + 1 pl. 1954.

W. E. Ritter was a man of original views, a first-rate biologist of the generation of Conklin, Morgan, Harrison, and Wilson who decried the increasing tendency of biologists to adopt a naive materialism as their philosophical view of life—and one who upheld the fundamental necessity of religion in the life of man in the face of fellow-scientists who regarded religion as either the opiate or superstition of the people. He found little sympathy among either his contemporaries or the younger generation for his views. Nevertheless, as we read here the distillation of his lifelong thought, it is not to be brushed lightly aside. Ritter was both a man of culture and a sufficient logician to avoid narrowness on the one hand and cloudiness of thought or emotional perturbations of reason on the other.

His views embodied two major concepts, the one that of the Wholeness of the Organism and the other that of the primacy of Natural History as the intelligent appraisal of the world and man's place in it. By the wholeness of the organism he meant, obviously, to emphasize the integration of parts that so frequently escapes the analytical eye; and by "natural history" he meant an approach to all phenomena that takes into account the fullest possible appreciation of their interrelationships on all levels, from the level of atoms to that of behavior and spirit. His religion was thus fundamental, but no narrow sectarianism. Although he did not call it such, it seems to have been a genuine pantheism.

Ritter's admiration of Charles Darwin was rooted in his appreciation of the fact that Darwin was always, first and foremost, a naturalist in his approach to phenomena. The emphasis on the Golden Rule in the book's title was an effort to counteract the prevailing tendency to think of Natural Selection as the ruthless, if not cruel, exterminator of the unfit—of "nature, red in tooth and claw." Rightly seen, in full perspective, nature of course embraces death and the feeding of organisms upon one another, but natural selection has also evolved the parental care of the young, the love of harmless play, the emotional appreciation of beauty, and the mind and spirit of man, including his widespread recognition of the Golden Rule—"do as you would be done by." If in anything Darwin himself fell short, so Ritter thought, it was in that although he accepted the ethical nature of man as a product of evolution, yet he refused to explore for himself the metaphysical realm in which the observer looks at his own inner being, not with the eye of the senses which provide the data of "naive" or "analytical" naturalism, but with the eye of introspection, which provides data of "critical" or "philosophical" naturalism that also belong to natural history, in Ritter's broad sense.

Ritter himself thus arrived at a synthesis of emotion and reason, of religion and science in his own life and thought. Like Sinnott in recent years, he could be satisfied with nothing less than a philosophy that truly embraced the Wholeness of life. Scientists who would dismiss Ritter offhand as a mystic might well read these pages. Some may even end convinced that their own view of life and nature might need enlargement.

BENTLEY GLASS

PROCEEDINGS OF THE SUMMER CONFERENCE ON COLLEGE BIOLOGY JUNE 15–19, 1953, *sponsored by National Science Foundation.*

Editorial supervision by Harriet Harvey. University of Oklahoma, Norman. Free upon request (paper). iv + 144 pp. [No date.]

The purpose of this conference was to inquire into the question of what materials from various modern fields of biology should be included in an introductory biology course. The question was raised in the first place—and it is still being raised and considered by other committees and other conferences—because there is a general feeling that biology, as a subject, is out of date and no longer part of a liberal education, that its usefulness is generally restricted to the preparation of future medical men, and that biology fails to draw to itself the cream of the bright young students. Most biologists would agree that these fears are well grounded in fact, and in their search for a way out, they have seized upon the general course as a convenient whipping post. There is a widely accepted assumption that if the introductory course in biology were truly modernized it would serve both the future professional scientist as an introduction and the non-biologist as a liberalizing element in his education. The flow of good students into biology would follow as night follows the day. The proceedings of this conference reveal that there is no agreement as to what is meant by the "modernization" of a course—this is clearly indicated by the divergent views expressed by the ten principal speakers and the many more discussants—just as there is no agreement as to the reason why biology fails to attract the best young people to it. There is agreement, however, in considering that any introductory course should be a dynamic one emphasizing causal explanations of phenomena rather than merely describing them, should show the interrelationships of all branches of biology, and should reveal the relation of biology to other sciences and to everyday existence. This takes careful arrangement of material, a good textbook, and an inspiring teacher—with the last being by far the most important.

C. P. SWANSON

LABORATORY STUDIES IN GENERAL BIOLOGY.

By Ray L. Watterson, Ralph O. Freeland, and Robert Hull. Burgess Publishing Company, Minneapolis. $2.25 (paper). vi + 143 pp.; ill. 1954.

LABORATORY STUDIES IN BIOLOGY. *Observations and their Implications.*

By Chester A. Lawson, Ralph W. Lewis, Mary Alice Burmester, and Garrett Hardin; illustrated by Evan L. Gillespie. W. H. Freeman & Company, San Francisco. $3.50 (paper). viii + 328 + xii pp.; ill. 1955.

There are many laboratory manuals available for general biology courses, each of them designed for some particular approach to the subject. Most of these manuals leave a great deal to be desired, and occasionally force the conscientious instructor to write his own. However, the quality of general biology laboratory manuals is improving, and these two additions to the field are an indication of the trend. Although of quite different natures, they are among the better ones available today for the full-year introductory biology course which is frequently taken by students who do not major in science. They both include a considerable amount of experimental work that can be carried out in most college laboratories.

The Watterson, Freeland, and Hull manual utilizes at the very beginning of the course the intense interest stimulated by the dissection of the fetal pig. In the first of the three sections of the manual, mammalian anatomy, histology, and physiology are well integrated by system, with some reference to the lower chordates. Part II consists of exercises on embryology and genetics —the latter including *Drosophila* breeding experiments —and a survey of the animal kingdom, emphasizing the basic activities shared by all animals. The entire third section is devoted to a rather thorough consideration of the plant world, and here, too, a number of experimental procedures are used. Most of the necessary drawings are supplied, and those in the third section are to be labeled by the student. The illustrations are of good quality throughout.

The manual by Lawson, Lewis, Burmeister, and Hardin is fancier, and consequently more expensive. The pages are designed to be removed and later reassembled into a 3-ring binder. This manual differs somewhat in concept from the first one, and employs a "problems" approach which asks the student a great many questions, leaving space for the expected answers. It attempts to stimulate in the student a spirit of discovery rather than demanding mere verification; it encourages him to form hypotheses and to test these by actual observations and experiments. The exercises on heredity, cycles and food chains, and the relation of population structure to evolution are distinctive. Perhaps there is some justification for retaining the frog as an example of vertebrate structure, although the fetal pig would serve just as well, if not better.

FRANK C. ERK

BIOLOGY: HISTORY AND BIOGRAPHY

PORTRAITS FROM MEMORY. *Recollections of a Zoologist. By Richard B. Goldschmidt. University of Washington Press, Seattle.* $3.50. x + 181 pp. + 8 pl. 1956.

The biological career of Professor Goldschmidt began in 1896, a decade or two after the foundations of cytology, protozoology, embryology, and comparative anat-

omy were laid. Genetics had not yet been rediscovered, but experimental biology, as distinguished from the descriptive aspects, had already become the vital force it still is today. Germany was the center of this new foment of activity, and Richard Goldschmidt, who as a student had his early training and associations in this atmosphere, recaptures it again through the personalities of that era and the experiences of contact and study with these men.

Some of them had already achieved greatness when Richard Goldschmidt began his studies: Leydig, Kölliker, Haeckel, Müller, Leuckart, Gegenbaur, Bütschli, who was Goldschmidt's teacher, the brothers Hertwig, Driesch, Boveri, and others. Later came Schaudinn, von Prowazek, Bělář, and others of lesser brilliance, but contributors all. Interspersed with the intimate portraits which Goldschmidt has drawn are relevant discussions of prevailing philosophies; the interest all of them seemed to share in art as well as in science; the intellectual environment of the universities at Heidelberg, Munich, Berlin, Jena, and Bonn; the social hierarchy of university life; the tribulations and status of the privat docent; and the enormous vitality of a burgeoning scientific age. So far as Goldschmidt's own scientific contributions are concerned, this is a minor publication, but to those of us who can enjoy these experiences vicariously, it is a very real addition to biological history.

C. P. SWANSON

THE FUNDAMENTALIST CONTROVERSY, 1918–1931.

By Norman F. Furniss. Yale University Press, New Haven; Geoffrey Cumberlege, Oxford University Press, London. $3.75. x + 200 pp. 1954.

For biologists who may be interested in the background of the Scopes "monkey-trial" or who are concerned as to the reasons for the rampant attack upon evolutionary theory which marked the 'twenties, here is a scholarly treatment of the entire Fundamentalist controversy. Part One consists of an analysis of the Fundamentalist Crusade; Part Two takes up the secular aspects of the controversy; and Part Three makes the round of the Protestant denominations, one by one. The result, for all its dryness, is devastating—a chapter of American history that everyone who wants to understand America and Americans will have to read. It might have been called: From Bryan to the Political Demise of Fundametalism.

It would nevertheless be a grave mistake to conclude, as some readers may, that the issue is dead rather than dormant. In 1942 the undersigned was coauthor of a committee report in which data from the biology teachers of public, parochial, and private high schools sampled over the entire United States revealed that almost half of them were unable to teach organic evolution as an established theory or principle underlying plant, animal, and human origins. In many parts of the United States opposition is still strong, as any group of entering college freshmen will demonstrate. Yet it is encouraging that at least the recent issues of *Life* dealing with the evolution of plants, animals, and man were not actually banned in any community, so far as known. When the *Reader's Digest* is equally bold, the final battle will have been won.

BENTLEY GLASS

BIOGRAPHICAL MEMOIRS. *Vol. XXVIII.*

National Academy of Sciences, Washington, D. C. [Columbia University Press, New York]. $4.00 (paper). iv + 312 pp. + 10 pl. 1954.

These memoirs include the biographies of the following deceased members of the National Academy of Sciences, with the author indicated in parentheses: Francis G. Blake, medical teacher, investigator, and administrator (J. R. Paul); Gano S. Dunn, engineer (V. Bush); Merritt L. Fernald, botanical systematist (E. D. Merrill); Frederick G. Gay, medical educator and bacteriologist (A. R. Dochez); Edwin B. Hart, agricultural biochemist (C. A. Elvehjem); Ludvig A. Hektoen, medical pathologist (P. R. Cannon); Raymond A. Kelser, veterinary bacteriologist (R. E. Shope); Elmer A. Sperry, physicist and inventor (J. C. Hunsaker); George L. Streeter, human embryologist (G. W. Corner); and Frank C. Whitmore, chemist (C. S. Marvel).

THE RAY SOCIETY. *A Bibliographical History.*

By Richard Curle. Printed for The Ray Society, London; sold by Bernard Quaritch, London. 10s. 6d. vi + 101 pp. + 1 pl. 1954.

The Ray Society, named after one of England's eminent early naturalists, was founded in 1844 to promote the natural sciences by publishing a variety of works not normally handled by existing societies or publishing houses. As such, it has been of considerable influence in bringing to light important studies which would have gone unpublished because of high costs or limited circulation. Although the heyday of the elaborately illustrated monograph is over, the need still exists for a society that can finance such ventures. The present volume is a brief study of the aims and the activities of the Ray Society since its inception. It is clear that it has been, and still is, an important and much needed society in the biological sciences.

THE SCIENTIFIC REVOLUTION 1500–1800. *The Formation of the Modern Scientific Attitude.*

By A. R. Hall. Longmans, Green & Company, Lon-

don, New York, and Toronto. $3.75. xviii + 390 pp. + 1 pl.; text ill. 1954.

This scholarly work is in the tradition of the great contributions to the history of science which have emanated from the University of Cambridge, from the time of Whipple to more recent students such as Charles Raven, Herbert Butterfield, and Joseph Needham. The biological materials are to be found chiefly in four chapters of the work: the first, Science in 1500, in which the belief in spontaneous generation is discussed in the light of the origins of natural history and scientific biology; the second, New Currents in the Sixteenth Century, in which the *De Humani Corporis Fabrica* of Vesalius and the *De Revolutionibus Orbium Coelestium* of Copernicus, both published in 1543, are contrasted in an illuminating way; Chapter Five, Experiment in Biology, devoted chiefly to William Harvey as exponent of experimentation; and Chapter Ten, Descriptive Biology and Systematics, which focuses on Linnaeus.

The object of the book being to trace the origin of a truly novel approach to nature, the method of scientific investigation, this volume is no complete or chronological account of the history of science. What it tries to do is to document the origin, fruition, and vindication of the scientific approach. In the words of the author: "In many . . . respects modern science differs markedly from that of a not very remote past. It demands rigorous standards in observing and experimenting. By insisting that it deals only with material entities in nature, it excludes spirits and other occult powers from its province. It distinguishes firmly between theories confirmed by multiple evidence, tentative hypotheses and unsupported speculations. It presents, not a possible or even a plausible picture of nature, but one in which all available facts are given their logical orderly places. These are the most important characteristics of modern science. . . ."

The conclusion is in some ways all the more surprising, that ". . . contrary to the straightforward inductive view of science, it has often happened that men have looked for facts to demonstrate a theory, as Galileo, Boyle and Newton did, without science being any the worse for that. . . . We may admit more. If modern science is not merely an elaborate digest of pointer-readings, then it is the more obvious that the scientific revolution involved more than the discovery of ways of making such readings and digesting them into a coherent synthesis. In the growth of modern science creative imagination, preferences, assumptions and preconceptions, ideas of the relation of God and Nature, arbitrary postulates, all played their parts. Here then is the crux; that we cannot write the full history of science save by reflecting the operations of original thought, which we do not understand; and that we cannot exclude from science, which is rational, the influence of factors which are irrational."

Has anything finer and truer been said about the nature and history of science?

BENTLEY GLASS

ON THE NATURE OF HISTORY. *Essays About History and Dissidence.*

By James C. Malin. James C. Malin, Lawrence. $3.00 (paper). viii + 290 pp. 1954.

This privately printed volume contains 8 essays by a historian who has attempted to introduce into his historical work a scientific orientation especially of an ecological, geographical, and technological aspect. According to the author, "these innovations widened the breach with traditional theory of history as a whole, and furthermore, challenged many traditions associated with the sciences utilized." The essays included are on the following topics: On the nature of history; History in relation to the social thought of P. W. Bridgman; History in relation to aspects of field theory; Historians and geography; From Missouri to Kansas: the case of H. Miles Moore; The nature of the American Civil War: the verdict of three Kansas democrats; The Wirt Case; and The problem of conservative and liberal traditions in the historiography of the United States: a plea for objectivity in history. Only the first four of these have much relation to the scientific point of view. Malin criticizes sharply the influence upon history of the pragmatists (John Dewey), the subjective relativists (Robinson, Becker, Beard, Curti), and the adherents of Turner's frontier hypothesis (Turner, Curti, et al.). He favors the views of the geographers Carl Sauer and Richard Hartshorne. Although Malin's present volume of essays by no means has the significance of his work on *The Grasslands of North America: Prolegomena to its History*, it deserves a hearing from those who are interested in the relation of scientific concepts to the social studies.

THE JOHNS HOPKINS HOSPITAL SCHOOL OF NURSING 1889–1949.

By Ethel Johns and Blanche Pfefferhorn. The Johns Hopkins Press, Baltimore. $4.50. xvi + 416 pp. + 9 pl. 1954.

Over 3000 student nurses graduated from the Johns Hopkins School of Nursing in the sixty years covered by this volume, and it is during that period that the Hospital, the School of Nursing, and the adjacent School of Medicine reached a stature which placed them in the forefront of the fight against disease. Of this triumvirate, the school of nursing played its usual vital role, but it remained inevitably in the shadow of the other two institutions. The present volume helps to correct this situation by providing a readable and

informative history of the women and, to a lesser extent, the men who were involved in making the Hopkins name synonymous with advanced medicine and nursing.

THE YOUNG NATURALIST

TEEN-AGERS. *A Health and Personal Development Text for All Teen-Agers. With Special Interest for 14, 15, 16 Year-Olds.*

By Gladys Gardner Jenkins, W. W. Bauer, and Helen S. Shacter. Scott, Foresman & Company, Chicago, Atlanta, Dallas, San Francisco, and New York. $3.60 288 pp. + 8 transparent pages; text ill. 1954.

The teens represent a period of change: new situations, social and psychological, arise; new vistas are opened; new potentialities are in the process of development. These create problems which the teen-ager must face. When they coincide with profound hormonal and physiological changes they can become serious unless faced courageously and sympathetically. This volume, which is intended as a textbook for high school students, attempts to aid the teen-ager by anticipating the problems or by meeting them squarely when once arisen. It sticks mainly to problems of health and personality, the only serious omission being that of sex and sex hygiene. The authors may have assumed that this subject cannot be treated successfully in a textbook of this type; it is, however, a subject which can scarcely be avoided, and must be faced sooner or later.

BIOLOGY ACTIVITIES. *With Achievement Tests, Form B. By B. B. Vance, C. A. Barker, and D. F. Miller; in consultation with W. R. Teeters. J. B. Lippincott Company, Chicago, Philadelphia, and New York.* $1.48 (paper). 256 pp.; ill. 1954.

This is a paper-backed combination laboratory manual, textbook, and reference list for high school students of biology. The practical aspects of biology are strongly emphasized, and the arrangement of the material is such as to force as well as encourage the student to read widely and independently.

ECOLOGY AND NATURAL HISTORY

THE DISTRIBUTION AND ABUNDANCE OF ANIMALS. *By H. G. Andrewartha and L. C. Birch. The University of Chicago Press, Chicago.* $15.00. xv + 782 pp.; ill. 1954.

This book discusses the classical ecological problems of the distribution and abundance of animal populations. These are considered to be facets of the same problem. In place of accepting the population as a basic unit and the division of environmental factors into physical and biotic, or into density-dependent and density-independent, the environment of an animal is divided into four components: (i) weather, (ii) food, (iii) other animals, and organisms causing disease, and (iv) a place in which to live. A large part of the book is devoted to a discussion of the ways in which the components of the environment may influence the rate of increase, which is determined by the constituents, fecundity, speed of development, and duration of life of a species. Diapause, dispersal, and the genetic aspect of ecology are also considered. Much of the text consists of an analysis of natural and laboratory populations—particularly those of insects. The general theory developed is that the numbers of animals in a natural population may be limited in three ways: (a) by shortage of material resources, such as food, places in which to make nests, etc.; (b) by inaccessibility of these material resources relative to the animals' capacities for dispersal and searching; and (c) by shortage of time when the rate of increase is positive. Of these three ways, the first is probably the least, and the last is probably the most, important in nature. Concerning the last factor, fluctuations in the value of the rate of increase may be caused by weather, predators, or any other component of environment.

This book is a significant contribution to a controversial subject. The analyses of laboratory and natural populations are made in a critical manner and the limitations of many standard procedures, for example, the logistic curve, are clearly indicated. The bibliography is extensive, and along with the text provides an introduction to the many subjects discussed. The general theory for the regulation of the numbers of animals probably underestimates the role of the population itself, but it will form the basis for much more detailed investigations of natural populations.

T. BURNETT

THE MARINE AND FRESH-WATER PLANKTON. *By Charles C. Davis. Michigan State University Press, East Lansing.* $10.00. xii + 562 pp.; ill. 1955.

Covering the whole of the marine and fresh-water plankton in a text of less than 300 pages is an ambitious undertaking that one may anticipate will not have been very satisfactorily accomplished, since any given topic can be treated only briefly. The general tone of the book is about at the undergraduate level or that of the beginning student of ecology. At this level, however, the clear definitions and explanations of ecological terms and concepts in the first part of the book should prove valuable aids. Something is said about many topics, but of course there is not sufficient space for an extended discussion of any; hence one is apt to be left

with some feeling of dissatisfaction. About half of the text is taken up with descriptions of and keys to the groups of planktonic organisms, accompanied by numerous figures mostly arranged in plates at the rear of the book. The basic difficulty of all ecological studies is identification, and I myself rather doubt the ability of students to identify by means of keys. However, as these keys are carried only to genera they may be of some assistance. A prime difficulty of keys of this type is that they are never complete and inclusive, and students tend to force specimens into such genera as are included in the key. As is often the case with keys and manuals, there seems to have been no selection of the more common forms, those most likely to be met with. The illustrations would have been easier to use if the scientific names had been printed directly below them. The book closes with a glossary of terms not explained in the text and a bibliography to which references are given throughout the text. Beginning students of the subject will undoubtedly find this book useful and helpful.

L. H. HYMAN

DJUREN I FÄRG. *Däggdjur—Kräldjur—Groddjur. Text by Kai Curry-Lindahl; illustrations by Karl Aage Tinggaard. Almqvist & Wiksell, Stockholm.* S.Kr. 11.00 (cloth); 8.75 (paper). 172 pp.; ill. 1955.

This volume, which follows an earlier one on the fishes, concerns itself with the common amphibians, reptiles, and mammals of the Scandinavian area. The 64 excellent plates depict 109 species in watercolor, while the text, which is in Swedish, gives descriptive, ecological, and economic information for each form. As a paper-backed edition, it should provide an inexpensive but useful handbook.

C. P. SWANSON

OUR BEAUTIFUL WESTERN BIRDS. *Observations of a Naturalist. By Russel T. Congdon. Exposition Press, New York.* $9.00. 408 pp. + 4 pl.; text ill. 1954.

This is a record of 175 excellent bird photographs taken by a surgeon and amateur photographer. The text makes no pretense of being scientific, but aims to let the reader participate in the pleasures of bird watching. Scattered through the pages are many observations on the habits of Western birds. On the whole, however, the author seems to have been far too busy with the mechanics of photography to make a real contribution to our knowledge of birds.

ERNST MAYR

AMERICAN BIRD SONG. *Volume One: Second Issue. Recorded by R. P. Kellogg and A. A. Allen for the Albert R. Brand Bird Song Foundation. Cornell University Records, A Division of Cornell University Press, Ithaca.* $7.75. 33⅓ RPM LP. 1954.

A transfer to LP of the records previously issued on 78 r.p.m. shellac discs, with some improvement in quality, a considerable reduction of surface noise, and a great improvement in convenience if one wants to hear the recording straight through—but no improvement at all if one wants to find a particular song. On hi-fi sets there is still an unpleasant boom or reverberation on certain tones, probably because of resonance in the recording system.

CALIFORNIA GRIZZLY. *By Tracy I. Storer and Lloyd P. Tevis, Jr. University of California Press, Berkeley and Los Angeles.* $7.50. xii + 335 pp. + 26 pl.; text ill. 1955.

Symbolic of the untamed and challenging west, the grizzly bear of the California Territory, more than any other animal, captured the imagination of all who read of, or followed, the boisterous history of that region. While its extermination was an inevitable milestone of progress toward civilization, its passing has been regretted by many, and the account of its times by Storer and Tevis is a fitting monument to its memory.

During the time of the Spanish occupation, the bears apparently began to increase in numbers, and by the time of the gold rush they were so abundant as to be a major deterrent to stock raising. The American settlers and miners, in contrast to their Spanish predecessors, hunted the big bears vigorously and unrelentlingly. As a result, within 70 years following the gold rush, the species was extinct in the state. The history of its heyday and of its passing has been drawn from diaries, newspaper stories, and many biographies and historical accounts of life in early-day California.

The authors are to be commended for the degree of completeness they have attained in documenting the history and folklore about this grandest of all California mammals. Its history can never be complete, but this volume presents as fully as possible the history of its passing from the California scene. Lay reader and scientist alike will find both entertainment and critically evaluated data within its pages.

BRYAN P. GLASS

THE MONKEY BOOK. *By Ernest P. Walker. The Macmillan Company, New York.* $6.50. xii + 154 pp.; ill. 1954.

This little book is intended as a guide to those who wish to keep primates as pets. It will be found useful, how-

ever, by one who wishes to maintain unfamiliar primates in the laboratory. The author, who is Assistant Director of the National Zoological Park, Washington, D. C., is well qualified to give advice on the care of primates, both as specimens and as pets. The book is divided into two parts, the first of which covers general care and feeding. The second part provides more detailed information about 51 different genera of primates. Two pages are devoted to each genus, one for a picture (usually excellent), and the other for information about the size of the animal, its range, habits, feeding, etc. All of the commonly available primates are covered, as well as some which never appear in pet stores, such as the tarsier and the proboscis monkey.

Two features which make the book especially valuable to the prospective primate buyer are price quotations (as of 1951 but still reasonably current) and lists of common and colloquial names for each genus.

M. A. BENDER

THE RAIN FORESTS OF GOLFO DULCE.

By Paul H. Allen; drawings by Dorothy O. Allen. University of Florida Press, Gainesville. $8.50. xii + 417 pp.; ill. 1956.

The Golfo Dulce is a bay on the Pacific side of Costa Rica, and part of the adjacent region is watered by 200 inches of rain a year. This supports a type of rain forest more commonly associated with the humid Amazon basin, and produces an area essentially unspoiled by man and enormously rich botanically. Nearby lie the savannas, which by way of contrast are poverty-stricken in a botanical sense, and some of the great banana plantations of Central America. Taxonomic treatments of this and similar regions are greatly needed if proper exploitation of the marketable lumber is to be made, and it is this task which Paul M. Allen has undertaken. Recognizing that the taxonomy of a rain forest is enormously complicated by the fact that the time of flowering extends over the entire year, and that floral specimens from the taller species are often inaccessible, he has constructed a series of practical keys, based on climatic, edaphic, and transitional formations and any character which facilitates recognition at any time of year. The climatic formation keys include the evergreen lowland forest, littoral woodland, and lower and upper montane rain forests. The edaphic formations include the swamp forest, mangrove woodland, palm swamp, herbaceous swamp, and gallery woodland. The transitional formations are divided into savanna, pastures, fence row and trailside thickets, and second growth. One chapter considers the conspicuous species which are readily recognized, while another provides utilization lists to indicate the role these species play in the economy of the region and the world. The largest portion of the volume is taken up by an alphabetical index of families, genera, species, and common name, with each species described in considerable detail. A glossary and a number of black-and-white photographs conclude the volume.

To one who can make no claims to expertness in this field other than that of being an interested botanist, this appears to be an excellently conceived and executed piece of work, useful to those who work in the field as well as to those who, like myself, wish to know more of the vegetation quite foreign to our temperate zone.

C. P. SWANSON

CONTRIBUTION À L'ÉTUDE ÉCOLOGIQUE DES CÔTES ROCHEUSES DU SÉNÉGAL. *Mémoires de l'Institut Français d'Afrique Noire, No. 38.*

By R. Sourie. Ifan, Dakar. 2,400 fr. métro (paper). 342 pp. + 23 pl.; text ill. 1954.

This is an extended essay in the descriptive ecology of the shore flora and fauna, and of the environmental conditions in the neighborhood of Dakar. It fills a gap in this extensive literature, although its publication in a series devoted in large part to economic geography and ethnology may make it difficult of access to some students. The author introduces a number of new terms and redefines others; a useful index to the special terms is provided on p. 129. The photographic plates are good, and convey an adequate idea of the character of the shore under consideration. Many interesting details are clearly indicated by the numerous diagrams.

JOEL W. HEDGPETH

SEAWEEDS AT EBB TIDE.

By Muriel Lewin Guberlet; illustrated by Elizabeth L. Curtis. University of Washington Press, Seattle. $3.50. xvi + 182 pp.; ill. 1956.

Mrs. Guberlet is both a member of the English Department of the University of Washington and also a seashore naturalist of note. She has written widely in the natural history journals, and has several other semi-popular seashore books to her credit. The current volume is also for the generally uninformed, but interested, seashore dwellers of the West Coast who wish to know something of the flora that can be found between the reaches of high and low tides. After some brief notes on the methods of collecting, Mrs. Guberlet treats each species individually in non-technical language. Her descriptions are clear and concise, and, together with the accompanying line and wash drawings, should make identification relatively easy.

C. P. SWANSON

THE SINGING WILDERNESS.

By Sigurd F. Olson; illustrations by Francis Lee Jaques. Alfred A. Knopf, New York. $4.00. x + 245 pp.; ill. 1956.

This is a beautifully written book of a man and his response to the life that surges around him in the unbroken wilderness of northwest Minnesota and adjacent Canada. It has no particular theme, it advocates no particular point of view, and it attempts to drive home no particular lesson. It is the record of a man who is at peace with himself and his primeval surroundings, who enjoys, with rare sensitivity, the solitudes and simple existence of the self-sufficient woodsman, and who can write of his daily experiences and reflections with effortless grace and simplicity. Although the locale, the time, and the man are different, one is strongly reminded of Thoreau in his gentler moods. It is a book one will wish to come back to again and again.

C. P. SWANSON

PARADISE NORTH, *an Alaskan Year.*

By Henry D. Barrow; with drawings by Susan Barrow. The Dial Press, New York. $4.00. xiv + 242 pp.; ill. 1956.

SPRING ON AN ARCTIC ISLAND.

By Katharine Scherman. Little, Brown & Company, Boston and Toronto. $5.00. xviii + 331 pp. + 8 pl. 1956.

As their titles would indicate, both of these volumes fall into the category of travel-adventure books, and both deal with life in the far North. The first, *Paradise North*, tells of a year's study by a man and wife in a sheltered tide pool in south-eastern Alaska near Wrangell, with a boat as a home, and the tide pool as their limited scene of natural history exploration. The other skips to the east and to the north, where a party of eight, sponsored by the Arctic Institute of America and the New York Zoological Society, spent a brief time exploring and collecting on Bylot Island, a small piece of land lying just north of Baffin Island, and 450 miles inside the Arctic Circle. Five of the eight were scientists, the other three, including the author, presumably going along for the ride.

Since neither author is a trained scientist, the books provide only light reading, being largely descriptive and anecdotal in character. Although the reviewer enjoyed the descriptions of Bylot Island more than those of Alaskan tide pools, both books are rather mediocre and cannot seriously be recommended as outstanding volumes.

C. P. SWANSON

THE LIFE OF THE SPIDER.

By John Crompton; introduction by Alexander Petrunkevitch. The New American Library, New York (A Mentor Book). 35 cents (paper). 192 pp.; ill. 1954.

A paper-backed reprint edition of a book both good and bad (*Q. R. B.* 27: 313. 1952).

BIRDS OF THE WORLD. *Their Life and Habits.*

By Paul Barruel, translated by Phyllis Barclay-Smith. Oxford University Press, New York. $12.50. 204 pp.; ill. 1954.

HOW TO DRAW WILD ANIMALS OF THE COUNTRYSIDE.

By W. S. Hunter. The Studio Publications, London and New York. $1.50. 63 pp. 1954.

ANIMAL TRACKS. *The Standard Guide for Identification and Characteristics.*

Introduction by R. Marlin Perkins. The Stackpole Company, Harrisburg. $2.50. 64 pp.; ill. 1954.

The average person walking out-of-doors sees very few wild animals. Even the experienced naturalist must look long and carefully. But after a snowfall or in fresh mud there is ample evidence that the fields and woods are indeed populated with myriads of animals. And each footprint is the personal signature of its owner. But one must learn to read these signatures.

This small volume is the key to days of great pleasure for those observant enough to see animal tracks and possessed of enough curiosity to wish to understand them. For each of the forty-two North American animals treated, there is a concise account of means of identification, characteristics, food, and breeding. For many species there is a beautiful and accurate sketch of the animal by the renowned Canadian artist Luis M. Henderson. There are maps showing distribution; there are accurate sketches of footprints and tracks. The author, director of the Lincoln Park Zoo, Chicago, has presented a volume dedicated to all lovers of the outdoors and particularly to the young. This is a beautiful and fascinating book.

V. G. DETHIER

EVOLUTION

STRATIGRAPHICAL PALAEONTOLOGY. *A Study of Ancient Life-Provinces. Second Edition.*

By E. Neaverson. Oxford University Press, New York. $16.80. xii + 806 pp. + 18 pl.; text ill. 1955.

Although the title-page of this volume bears the notation, "Second Edition, Revised and Enlarged," it differs so greatly from the first edition, which appeared in 1928, as to constitute in large part a completely new work, despite the fact that much of the first edition

(which included 525 pages) has been incorporated with but little change. This seeming anachronism results from the fact that the first edition considered only the British faunas, while the present volume adds synoptic discussions of the faunas from other parts of the world, together with suggestions as to their correlations with those of Britain. The sections on the faunas of Britain and Wales are largely reprinted from the first edition, but those on the world faunas are entirely new. Since the latter represent essentially a pioneer attempt to review the world fossil succession on such a scale, they constitute an important and valuable contribution to paleontological literature.

Three chapters, on Tetrapod Faunas of the Late Paleozoic Systems, Mesozoic Land Faunas, and Neozoic Mammalian Faunas, offer a valuable and readable summary of the evolution of the vertebrate faunas, while a single chapter, on Fossil Land Floras, attempts to do the same for the plant sequence. Otherwise the emphasis of the text is, logically, based upon the invertebrate successions, with the marine faunas being treated in most detail. The body of the work is devoted to a discussion of the faunas of each of the geologic systems. In each of the systemic chapters the faunas of Britain and Wales are discussed in detail, particular emphasis being given to those genera and species that are of special value as guide fossils. Little descriptive information is given, and proportionately few are illustrated; hence the reader needs to have some first-hand knowledge of the fossils to reap the greatest value from these sections. The latter part of each chapter, usually about one-third to one-half of its total length, is devoted to the consideration of contemporaneous world faunas. As mentioned above, the sections on the British faunas are largely reprinted from the first edition; a noteworthy exception, however, is the discussion of the classic Jurassic section of England, the treatment of which has been much enlarged and modernized, possibly reflecting the influence of Arkell's definitive work on this system in Great Britain. Unfortunately, the reprinting has extended so far as to include the systematic bibliographies, which conclude each chapter. These mention but few works that have appeared since the issue of the first edition, and generally, only those by British authors. Similarly, there is a noticeable and regrettable lack of reference to more recent work in the newly appearing sections on the world faunas. The student of the North American stratigraphy, for example, will find many out of date correlations and much superseded information, together with a lack of reference to many significant studies published during the past twenty-five years.

Biologists will perhaps be most interested in the introductory and the concluding chapters, especially those on Preservation and Distribution of Fossils and Fossils as Guides to Horizons, and the final chapter, General Relations of Continents and Oceans: A Summary of Conclusions. The first of the chapters mentioned is essentially a reprinting of chapters III to V of the first edition, but still remains a valuable and readable summary of the topic, despite the fact that it does not include any consideration of more recent works pertinent to the subject. The second is essentially a synopsis of the geologic history of the animal phyla; plants are but briefly mentioned.

The concluding chapter is, in my own opinion, by far the most interesting and stimulating in the work. It includes a short paleogeographic history of each continent with a review of its land faunas, and a similar treatment of the oceans and their faunas, with considerations of possible former connections between the continents and also between the oceans. The conclusions are well summarized in the following paragraph, which is the final one in the book:

"It has become evident that the palaeontological features of the several stratigraphic systems afford no support to the hypothesis of large transoceanic land bridges as advocated by J. W. Gregory (1929–30) and others in the early years of this century. The hypothesis, though based on incomplete evidence, was held to explain certain apparent anomalies in palaeontological evidence, but some of these have been otherwise resolved as a result of subsequent exploration. It is equally certain that the theory of Continental Drift, envisaged by A. Wegener (1921) and A. Dutoit (1937), is inconsistent with the facts of palaeontological history, and that the theory is bolstered by faulty interpretations of faunal relationships, some already discredited by competent palaeontologists. On the contrary, the evidence of marine faunas throughout the ages is consistent with the older view of stable ocean basins with fluctuating margins, and the continental faunas show such a measure of isolation that the land-masses of the globe must have had approximately their present relations during the whole history of the tetrapod animals."

The work concludes with complete and full paleontological, stratigraphical, and geographical indices.

All in all, while it is easy to be critical of the work, it must be emphasized that it contains so much of significance and value that it deserves a position on the ready-reference shelf of all paleontologists and stratigraphers. There is no other work in any language that can compete with it in its coverage of world paleontology from the viewpoint of faunal successions.

H. E. VOKES

ANIMAL SPECIES AND THEIR EVOLUTION.

By A. J. Cain. Hutchinson's University Library, London, New York, Toronto, Melbourne, Sydney, and Cape Town; [Longmans, Green & Company, New York]. $2.40; 8s. 6d. 190 pp.; ill. 1954.

This is a very comprehensive and well-balanced discussion of the problem of animal species as currently

viewed by students of evolutionary processes. The chapter on Rank, succinct but extremely lucid, has rarely been excelled in discussions of the hierarchical system of classification. It should become a classic. There is a good discussion of Polytypic Species, in which it is stressed that the "morphospecies," static, monotypic, and excluding considerations of variation throughout space and time, is still of necessity used to classify most of the animal kingdom; whereas in actuality the polytypic species, the Rassenkreis, and other geographically definable population groups form a more realistic basis, whenever the material is available. A chapter on the Biological Species emphasizes—probably overemphasizes—the distinctiveness of species in nature on the basis of failure to hybridize when they meet. The pertinent example to consider over against so strong an assertion of that single criterion of species distinctness is the accepted *generic* distinction between Alaskan brown bear and polar bear, which do not hybridize in nature seemingly because they just never meet, although they are quite capable of interbreeding, with good fertility of the hybrids. The problem of sibling species is also examined, Cain's conclusions being in good accord with those of Dobzhansky on this matter. Other Sorts of Species is a chapter which treats of the "agamospecies," set up through necessity in animal groups not reproducing sexually; "palaeospecies," which are necessarily purely morphological in basis; and the "biospecies" of sexually reproducing animals, varying in time and space, usually polytypic, and usually set off from its nearest relatives by genetic barriers. The general concepts developed here are in good accord with earlier discussions of the nature of species by such writers on evolution as Julian Huxley and Ernst Mayr.

The book concludes with two chapters respectively on Geographical Speciation and on Sympatric Speciation. The point of view is again like that of Mayr. Although Cain would not exclude the possibility of occasional sympatric speciation, he thinks it obviously must be rare and of little general evolutionary importance. It is certainly not supported by the substantial body of evidence which exists for geographical speciation.

BENTLEY GLASS

MAN IN SEARCH OF HIS ANCESTORS.
By André Senet; translated by Malcolm Barnes. McGraw-Hill Book Company, New York, Toronto, London. $5.50. xii + 274 pp. + 12 pl.; text ill. 1956.

Everyone has asked himself at one time or another, "From whence have I come?"—and the popularizers of science have seized upon this and have provided the reading public with some rather excellent volumes. The movement has also been furthered by the story of the Piltdown hoax, even though among modern anthropologists the Piltdown man occupied no central and critical position in the evolutionary chain of man. The present volume is another attempt to place man in his proper place in the scheme of living things, and the attempt can be best characterized by saying that after a rather delightful paleontological exposition, it falls down badly in its evolutionary and genetical interpretations.

Senet begins by considering the hunt for fossil men and the connections which might be established with the existing great apes. Of particular interest are his discussions of the early paleontologists who participated in this study, and of prehistoric life and art as portrayed on the walls of the great French caves. He then traces the evolution of the animal kingdom in general, sketching out the main lines of descent and indicating where uncertainty exists and where the evidence seems reasonably substantial. In doing this, the author handles his material surely and judiciously, at all times keeping the story light and alive by anecdotal inserts of men and places. It is only when he comes to the mechanisms and the manner of evolution that Senet shows an uncertainty of touch. He is quite willing to let the reader believe that neo-Darwinism and neo-Lamarckianism share the same billing on the evolutionary stage, and that more information must be obtained before one or the other departs backstage and into oblivion. In this regard, he discusses G. G. Simpson's attempt to bring a genetical point of view into paleontology and he admits, almost reluctantly and sadly, that Simpson is forced to a neo-Darwinian stand.

In considering the origin of life on earth, Senet is apparently unaware of Oparin's work, and considers the Dauvillier-Desguin theory, advanced in 1939, as the only one worth considering. This theory, apparently based on Oparin's idea, considers that the short ultraviolet, acting upon an oxygen-free atmosphere of carbon dioxide, ammonia, and water vapor, created a photosynthetic-like production of carbohydrates. These, by chance combinations, produced amino acids. The critical point of this theory is that ultraviolet, on striking the water, gives light which is circularly polarized, and this leads to the synthesis of molecules of marked dyssymmetry such as characterize living organisms. The arguments seem particularly strained and meaningless in the light of modern ideas, and, in particular, of the experiments of Urey and Miller. Furthermore, it is postulated that these molecules eventually gave rise to viruses, and these to bacteria, etc. The multiplication of viruses by binary fission is also described, even though no known virus multiplies outside of a living cell.

In concluding, Senet, quoting Vandel, sees evolution as a directed process in "that all evolution seems to have developed in relation to man, that is to say that it has had as its aim the appearance on the earth of an individual with a large brain, with an intelligence much

more developed than that of the most intelligent the of animals. And this individual is man." Such an orthogenetic and predetermined point of view, while more typical of paleontologists, is hardly likely to find acceptance in modern biological circles. Senet's treatment of the process, mechanisms, and aims of evolution does much to detract from what is otherwise an interesting and readable account of man's ancestors.

C. P. SWANSON

MAN AND THE VERTEBRATES. *Volumes 1 and 2.*

By Alfred Sherwood Romer. Penguin Books, Baltimore. 85 cents each (paper). (1) x + 198 pp + 64 pl.; text ill. (2) Pp. 199–437 + 64 pl.; text ill. 1954. Reprint edition.

GRUNDRISS DER ENTWICKELUNGSGESCHICHTE DES MENSCHEN. *Fourth Edition.*

By Otto Grosser and Georg Politzer. Springer-Verlag, Berlin, Göttingen, and Heidelberg. DM 14.50 (paper). viii + 159 pp.; ill. 1953.

GENETICS AND CYTOLOGY

DIE SEXUALITÄT. *Das Wesen und die Grundgesetzlichkeiten des Geschlechts und der Geschlechtsbestimmung im Tier- und Pflanzenreich.*

By Max Hartmann. Gustav Fischer Verlag, Stuttgart. DM 54. xvi + 463 pp.; ill. 1956.

The first edition (1943) of this work has long served as a convenient background for discussion, often controversial, of the fundamental biological mechanisms of sexuality and sex determination. Since it is now out of print and virtually a collector's item, this new edition will be welcomed. Unfortunately, it is basically a reprinting, and very little material has been added, the assimilation of recent work in English being evidently secondhand. Thus while the prewar literature on fundamental aspects of sexuality is richly displayed, the important and more recent contributions of Papazian, Pontecorvo, Raper, Sonneborn, Wheeler, and Whitehouse (to mention just a few microbiologists) are overlooked. However, Hartmann's book is still the most complete résumé of the genetic and cell-biological bases of sex, especially in the lower organisms.

Hartmann gives a four-part classification of sexual determination according to whether (a) it is genetic or environmental, and whether (b) it controls the haplont or the diplont. Each of the four categories is then exemplified at length, with a consideration of genetic and physiological factors which determine the patterns of sexual behavior, and the differentiation of the sexes. Bacteria and viruses are not mentioned, but a wide range of organisms, from unicellular algae and protozoa to flowering plants and the vertebrates, exemplifies the patterns of sexuality. The terminology is cumbersome, but the diversity of conditions in different organisms would be difficult to assimilate under any scheme. For example, *Acetabularia* is described as *diplophenotypic haplomonecious*: a single diploid thallus can produce cysts of two types, each containing haploid gametes of one or the other mating type.

Hartmann's principal theses are (1) that sexuality is always determined, either genetically or phenotypically, so that intrinsic diversity is a condition of sexual fusion; (2) that sexual differentiation stems from an originally bivalent tendency, with the exaggeration of either male or female potencies; and (3) that hence, maleness or femaleness can be manifested in various degrees of relative sexuality, so that a "weak male" may function as female when confronted with a "strong male." Much experimental support for the theory had come from the work of Hartmann's student, F. Moewus, a large part of which cannot now be confirmed by Hartmann's collaborators. This is therefore "weggelassen," whereas other parts of Moewus' work are retained in support of the theory. There is no doubt that relative sexuality presents an important biological principle which calls for further experimental consideration; the reviewer has himself invoked the concept as bearing on certain features of bacterial sexuality, for example. However, its manifestations on a cellular or on a populational basis should be distinguished. Thus, Dodge has described *Neurospora* strains which deviate from wild type in their failure to produce female (protoperithecia) and male (conidia) structures. These variants might be considered as males and females, respectively, while other cultures which show limited development of one of the sexual structures would be relative males and females. Nevertheless, no single cell of these cultures can be described as having a relative sexual potency. The issue of relative sexuality is met head-on in few studies of unicellular, isogamous species in pure culture, which would furnish its most critical test.

Another approach to the consideration of sexuality has been emphasized by Wheeler and Whitehouse, among others, who stress genetic recombination among diversified genotypes as the primary role of sexuality, the differentiation of sexual structures and mating types being secondary adaptations evolved to maximize outbreeding, rather than primary attributes of living matter.

J. LEDERBERG

CHROMOSOME BOTANY.

By C. D. Darlington. George Allen & Unwin, London; [The Macmillan Company, New York]. $2.75. xii + 186 pp.; ill. 1956.

Few scientists are as aware of the contributions made by cytogenetics to the whole area of biology as is the author of this book, and fewer still are those who have

contributed so extensively as individuals, or who have ranged so widely in their interests. Books and research articles continue to flow from his prolific pen, and although many have quarreled in the literature with Darlington, none can deny that his influence in biology has been profound and far-reaching.

The present volume attempts to bring together the varied chromosomal and genetic studies made on both cultivated and wild plant species, and to interpret these findings in the light of our knowledge of systematics, geography, and ecology. The raw data upon which these discussions depend are contained in a companion volume, *Chromosome Atlas of Flowering Plants* (see below). In organizing the material Darlington has broken it down into six categories. The first deals with the structure and behavior of chromosomes in division, the kinds of polyploids, and the appearance and significance of *B* as contrasted with *A* chromosomes. The second is concerned with systematics: the meaning of a species, their modes of reproduction, and their methods of variation through cytological and genetical change. Category three discusses ecology and geography from a cytological point of view, while the fourth considers chromosome numbers, individuality, and their rates of change as a function of time. The last two sections discuss cultivated and ornamental plants, with the special problems that each presents. In one sense the volume is an elementary form of Stebbins' *Variation and Evolution in Plants*, although the emphasis is more definitely cytological. On the other hand, it is a distinct and original contribution not only because it is based upon the enormous amount of data contained in the companion volume, but also because it is uniquely Darlingtonian in its approach. It is possible, of course, to take exception, and to offer alternative explanations to some of the author's generalizations, but this is to take a narrow point of view regarding the value of the book. Because of its stimulating discussions, presentation of new data, and different approach, the book is a valuable contribution to the working library of the cytologist, systematist, ecologist, and geographer.

C. P. SWANSON

CHROMOSOME ATLAS *of Flowering Plants.*

By C. D. Darlington and A. P. Wylie. The Macmillan Company, New York. 10s.50d. xx + 519 pp.; ill. 1956.

The predecessor of this volume, compiled by the senior author and Dr. Janaki Ammal, restricted its coverage to the cultivated plants. The present volume is not so narrowly conceived, and covers over 15,000 species of flowering plants of both cultivated and wild kinds. Some 2300-2400 references are given as source material. It represents a work of enormous magnitude and painstaking search, and the gratitude of cytologists, geneticists, and plant breeders is due the authors in every respect. As pointed out in the preface, the book has a three-fold purpose: (1) to convey to systematists the value of chromosome numbers as a solid basis for classification; (2) to indicate to plant breeders the genetic structure of plants and the limits within which successful interspecific or even intergeneric (as in the Rosaceae) crosses might be made; and (3) to reveal to cytologists what has been, and what remains to be, done.

In handling this vast array of data, the authors have followed, with but few exceptions, the families of angiosperms as given in Hutchinson's *Families of Flowering Plants*, and two-thirds of the families are represented. Forty-four genera of gymnosperms are also included, the family listings being those from Engler and Prantl. The dicots are arranged into 18 groups of related orders, the monocots into 6 such groups.

In the treatment of each species the following information is given: generic and specific name, popular or economic name, somatic chromosome number, references, and uses to which each is put. The presence of supernumerary chromosomes is also indicated, as are experimentally produced haploids and polyploids. One can readily appreciate, therefore, the amount of information crammed into this single volume.

The earlier volume carried a discussion of botanical cytology as it relates to systematics, ecology, and geography. This has now been deleted, and in an expanded form comprises a companion volume by the senior author entitled *Chromosome Botany* (see above).

C. P. SWANSON

CHROMOSOMES SEX-CELLS AND EVOLUTION IN A MAMMAL, *Based Mainly on Studies of the Reproductive Glands of the Gerbil and a New List of Chromosome Numbers of Mammals.*

By Phillip V. Tobias; foreword by Theodosius Dobzhansky. Percy Lund, Humphries & Company, London. £ 3. xx + 420 pp. + 12 pl.; text ill. 1956.

It is rather unusual in these days to see a Ph.D. thesis in the experimental biological sciences published in book form, and as a most substantial book of 420 pages. But a reading of the volume indicates that this is a contribution of quality as well as quantity, and it puts to shame many of the briefer theses which we customarily accept in this country from Ph.D. candidates.

In particular, Tobias' study is concerned with the cytology of reproduction in the male gerbil, a South African rodent of the family Cricetidae, subfamily Gerbillinae, and the chromosomal constants are then compared in detail with similar characteristics of the closely related albino rat. This comparison reveals that

the Muridae, in which the rat falls, is a much more cytologically uniform family than the Crecetidae, and that the variation in chromosome numbers in the Crecetidae is quite wide. The mechanism of change is generally from rods to V's, or the reverse, the gerbil showing a reduction in number as contrasted to the supposed base numbers of the family. The subfamily Gerbillinae, with 22 cytologically known species, has 13 different diploid numbers ranging from 72 to 34 (in the gerbil). An extensive discussion considers the mechanisms involved, and contrasts are made with other groups of plants and animals.

The remainder of the book deals with the details in the gerbil of mitosis and meiosis, including the premeiotic mitosis, and spermiogenesis; the structure and behavior of the nucleolus, sex-chromosomes, and heterochromatin; the spermatogenetic wave; and cytoplasmic behavior during spermatogenesis. In each instance, the particular observations made in the gerbil are exhaustively related to all else known in cytology which agrees with, or departs from, them. The result is a rather comprehensive treatment of mammalian cytology. Nothing remarkably new or novel appears to have been discovered, although it reaffirms, as Dobzhansky points out in his foreword, the cytological idea that there is unity within diversity, i.e., that the processes of reproduction are varied indeed, but that the end-result, perpetuating one's kind, is the same.

C. P. SWANSON

THE MUTANTS OF DROSOPHILA MELANOGASTER, *Classified according to Body Parts Affected. Pub. 552A. By Norma B. Braver. Carnegie Institution of Washington, Washington.* 25 cents (paper). vi + 36 pp. 1956.

SYMPOSIUM ON GENETICS OF POPULATION STRUCTURE. *Istituto di Genetica, Università di Pavia, Italy, August 20–23, 1953. Union Internationale des Sciences Biologiques, Ser. B, No. 15.*

Edited by Adriano A. Buzzati-Traverso. International Union of Biological Sciences, Naples. $2.30 (paper). 141 pp. + 1 pl. + 1 chart; text ill. 1954.

Prior to the 9th International Genetics Congress, held at Bellagio in 1953, a small group assembled at Pavia for a symposium on population genetics. These proceedings contain the 7 main papers presented there, together with some shorter discussions. Reports of the results of selection for abdominal chaetae in *Drosophila melanogaster* (G. Clayton, J. A. Morris and A. Robertson) and of the effectiveness of irradiation in permitting the resumption of progress in selection (R. E. Scossiroli) were coupled with papers partly experimental, partly theoretical on asymmetrical responses to selection in mice and rats (D. S. Falconer) and on the existence of coadaptation between the complexes in different gene arrangements in *Drosophila* (B. Wallace). Two papers dealt with plants: The ecological race as a variable biotype compound in dynamic balance with its environment (J. Clausen); and Quantitative variation in wild genotypes of *Clarkia* (H. Lewis). A. A. Buzzati-Traverso supplied Conclusions and Perspectives, and J. B. S. Haldane provided a closing word. Dobzhansky, Lerner and Epling contributed short notes. Although the symposium was by no means so extensive or comprehensive as the one on population genetics held at Cold Spring Harbor in 1955, there is important substance here, both from an experimental and from a theoretical point of view, which no students of genetics and evolution should overlook.

BENTLEY GLASS

HUMAN HEREDITY.

By James V. Neel and William J. Schull. The University of Chicago Press, Chicago. $6.00. viii + 361 pp.; ill. 1954.

This modest volume, not at all intended to be a compendium of human hereditary traits such as Gates' *Human Genetics*, is most comparable to *Principles of Human Genetics*, by Curt Stern. More than that book, however, which is an excellent introduction for the novice in the field, this one presupposes a certain sophistication which will require a command of calculus and biometry on the part of the reader and a genuine interest in the methodology of human genetics. It is in general no more difficult than need be, considering its aim, and will serve as an invaluable handbook to workers in the field.

The book begins by considering general aspects, such as the physical basis of inheritance, human genetic diversity, and the interplay of nature and nurture. Probability is explained in an elementary way, with a supply of good problems to test the reader's grasp. Next follows a treatment of dominant, recessive, and intermediate types of allelic interaction, followed by a consideration of more complex situations, linkage, and mutation. A brief excursion into physiological genetics is succeeded by two of the most mathematical chapters, dealing respectively with the Estimation of Genetic Parameters and Tests of Genetic Hypotheses, and with The Analysis of Family Data. An introduction to population genetics is then followed by a good critique of twin studies and the biases and pitfalls they conceal as well as the valuable insight they may provide. An all-too-short short chapter on Genetics and Epidemiology is succeeded by a triptych concerned with the Applications of Genetic Knowledge to Man: Counseling, Medicolegal Aspects, and Eugenics. Both author and subject indexes are provided.

The book is sound throughout, if not very readable—

the style at its best is terse, compact; at its heaviest didactic and overburdened with needless words. Apart from this, there is little to criticize except the incompleteness with which certain subjects have been treated. In my own opinion, the two chapters on population genetics and on human biochemical genetics suffer most in this respect. The former, for example, could have been enriched by a consideration of the dramatic clines in gene frequency demonstrated for blood group B across Asia and Europe by Candela, and of reciprocal clines for *CDe* and *cde* in the western Mediterranean Europeans by Mourant; of the study of random genetic drift in the Dunkers of southern Pennsylvania and of genetic differences in the castes of India; and of the dynamics of racial intermixture as seen in the effects of gene flow upon the composition of the N. American Negro population. Other aspects of population genetics and physiological and biochemical human genetics have recently advanced so rapidly that revisions are already needed, to permit inclusion of such interesting and important matters as the relation of sickle-cell trait and other abnormal hemoglobins to resistance to malaria and possibly other endemic diseases, or of the relative magnitudes of present exposures to ionizing radiation from fallout and from medical and other uses of x-rays. The work of the authors in these fields is so significant that the revision will be keenly anticipated.

The point of view of the authors is in general conservative and cautious, which is much to be desired in a field developing so rapidly in new directions. The chapter on eugenics is well-balanced and particularly commendable. In short, there are so many valuable things in this book and its treatment is in general so sound that minor deficiencies will be gladly overlooked.

BENTLEY GLASS

L'HÉRÉDITÉ EN MÉDECINE. *Caractères, Maladies, Corrélations.*

By A. Touraine. Masson & Cie., Paris. 7,200 fr. (cloth); 6,400 fr. (paper). 875 pp.; ill. 1955.

This is a mammoth compendium of information on the inheritance of human ailments. The pedigree method is the one principally used and many pedigrees from the literature are presented. It is almost exclusively continental literature which is covered. Curiously, there is no indication that the author is familiar with R. R. Gates' rather similar encyclopedic *Human Genetics* in two volumes (1946). The main usefulness of Touraine's volume to English-speaking medical geneticists will be that of a reference book from which to begin a literature survey of some particular disorder. Touraine makes reference to many publications which are likely otherwise to escape the attention of English-speaking workers. In general, the introductory chapters dealing with principles of human genetics seem to be written lucidly and accurately. The book probably compares favorably with any existing text on medical genetics in the English language. It should be highly useful to French-speaking physicians, since the author claims nothing comparable to it is otherwise available.

VICTOR A. MCKUSICK

A CLINICAL, PATHOLOGICAL, AND GENETIC STUDY OF MULTIPLE NEUROFIBROMATOSIS. *American Lecture Series, Pub. No. 281.*

By Frank W. Crowe, William J. Schull, and James V. Neel. Charles C Thomas, Springfield, Ill. $5.00. x + 181 pp.; ill. 1956.

In this study 127 families with 223 affected persons were subjects. Almost all aspects were investigated and are described in the monograph. Von Recklinghausen's neurofibromatosis is one of the multifaceted syndromes whose diverse manifestations, wide clinical importance, and frequent diagnostic confusion are derived from the fact that the "basic defect" has widespread repercussions and the range of expressivity of the phenotype is likewise wide. Both for the clinician and the geneticist these circumstances create an intriguing problem. The disease may present itself as acoustic neuroma, optic atrophy, scoliosis, overgrowth of a limb, pheochromocytoma, mediastinal tumor, paralysis, unsightly pigmentation, and/or tumors of the skin. The mechanism of the associated mental retardation is not known.

About 78 per cent of affected persons were found to have 6 or more café-au-lait spots of the skin, whereas no normal adult has this many. Sarcomatous degeneration occurred in 2 per cent, a figure which must be evaluated in the light of the fact that the average age of subjects was less than 30 years. The data of the study are all consistent with an autosomal dominant mode of inheritance. Furthermore, penetrance appears to be almost complete if thorough search for mild stigmata is made. The frequency in Michigan was estimated to lie in the range of 1 case in each 2500 to 3300 births, higher than most clinicians would suppose. Not fewer than 40 per cent of cases appear to be sporadic, i.e., without any other cases in the family.

The effective fertility of females (74.8%) and especially of males (41.3%) was reduced; in part the reduced fertility was social (reduced marriage rate), in part biological. The authors place the estimate for the mutation rate at about 1×10^{-4} per gamete per generation—the highest yet reported for a dominant trait. Neurofibromatosis is a particularly satisfactory disease for the investigation of the possibility of somatic mutation. Although the evidence is far from conclusive, four individuals were found who, by virtue of a sectorial limitation of lesions, "sporadic" incidence, and possibly reduced transmission of the disease, satisfy the a priori criteria for the occurrence of somatic mutation.

This monograph will be a classic on the subject.

VICTOR A. MCKUSICK

GENERAL AND SYSTEMATIC BOTANY

MOSSES. *A New Approach to the Identification of Common Species.*

By E. T. Bodenberg. Burgess Publishing Company, Minneapolis. $5.00 (paper). xii + 264 pp.; ill. 1954.

The author has selected 156 of the "most representative" mosses of the United States, and has described briefly, but rather well, their ranges, habitats, growth habits, and reproduction. Opinions will vary as to the wisdom of his selections. This restriction to a few mosses makes his keys to species invalid in certain areas, e.g., where species of *Anomodon* not in the key are common they may be identified as *A. attenuatus*. Each of the species is described by line drawings in plates 11–49, plates 1–10 illustrating morphological features. The drawings are of poor quality in many ways: capsules are out of proportion in respect to gametophytes (*D. heteromalla*, pl. 20), the plants have strange leaves in *Leucobryum* (pl. 21), and often gametophytes look identical (pl. 29).

Even though the book was written to appeal to the amateur, some difficult criteria are included to separate taxa. The cellular structure of the costa is used on p. 108 and "leaves papillose" appears in a field key (p. 74); both of these demand a compound microscope for accuracy.

There are some strange lapses: after listing two of Hedwig's earlier works the author does not mention his *Species Muscorum* (1801), which serves as a foundation for moss nomenclature. On p. 10 he says, "North of these regions lies the vast Subarctic Forest Region which embraces the whole of Canada, a region from which a great many species of moss migrate southward" —a statement difficult to defend. Editing too could have been better, e.g., "*Bryoxiphinus*" (p. 63) should be *Bryoxiphium*; "*Anomodon trista*" (p. 68) should be *A. tristis*, and the wrong pronunciation is indicated for flexuose on p. 247.

The index and glossary are extensive and very useful. The latter includes the pronunciation of the terms. The author's groupings of mosses on a basis of ecology, growth forms, and geographical range may be useful to beginners, but the book will not satisfy critical workers.

A. J. SHARP

LAUBMOOSFAMILIEN. *Bestimmungstabellen der Einheimischen.*

By Th. Herzog. Gustav Fischer, Jena. DM 56 (paper). 6 pp. + 2 folded charts. 1953.

BRITISH MOSSES AND LIVERWORTS. *An Introductory Work, with Full Descriptions and Figures of Over 200 Species, and Keys for the Identification of All Except the Very Rare Species.*

Written and illustrated by E. Vernon Watson; foreword by Paul Richards. Cambridge, at the University Press; [Cambridge University Press, New York]. $8.50. xvi + 419 pp. + 18 pl. + 26 pp. field keys; text ill. 1955.

Valuable to the amateur and ecologist as well as to the bryologist, this book will be useful to both American and British workers. An introduction of 24 pages initiates the beginner into bryology with an illustrated discussion of the characteristics of the bryophytes and of techniques for identifying and preserving them. An adequate glossary follows.

Keys are provided to the 310 mosses and 176 liverworts mentioned in the book, and field keys are included separately in a loose pamphlet in a pocket on the back cover. Both include many, although not a majority, of North American species.

Most of the text is devoted to rather full descriptions, including line drawings, of 154 mosses and 55 liverworts, each of which is followed by brief statements on their ecology. These descriptions are relatively nontechnical, clear, and adequate. Brief notes are given for an additional 156 mosses and 121 liverworts. Particularly good are the 18 full-page photographic plates.

The index, composed only of scientific names, is preceded by a list of 25 British habitats, most of which can be duplicated in America, and each accompanied by the names of mosses and liverworts expected there.

Exceptionally well-done for a manual of this size is the section on *Sphagnum* or the peat mosses, a group often neglected in spite of their economic and ecological significance.

A. J. SHARP

NEW CONCEPTS IN FLOWERING-PLANT TAXONOMY.

By J. Heslop-Harrison; with a foreword by W. B. Turrill. Harvard University Press, Cambridge. $1.25. viii + 135 pp.; ill. 1956.

Twenty-five years ago, when the reviewer studied the taxonomy of the angiosperms as a purely formal subject, the principal adjunctive sciences were morphology, ecology and geology, and the systematist was more or less concerned with static situations in which descriptive criteria seemed entirely adequate. Present-day systematics, while still relying upon description as the principal device for ready identification, is a more dynamic science, since it is concerned not so much with the fixed as with the variable aspects of morphology. Its boundaries have been enlarged, its approaches are more varied and more fluid, and its ultimate concern is with origins and mechanisms rather than with descriptive finality. Cytology and genetics, in particular, have infused taxonomy with new life, and studies of population variability—ecological, geographical, and cyto-

genetical—are yielding evidence which aids in an understanding of our present flora as but a phase in the stream of evolution. Turrill, Turesson, Stebbins, Edgar Anderson, and others were the early pioneers in this work, but the experimental approach can now be said to be the usual rather than the unusual among practicing systematists. Heslop-Harrison has done an excellent job in bringing the newer information and techniques together, and discussing them in terms of a "new" systematics.

C. P. SWANSON

COMMON EXOTIC TREES OF SOUTH FLORIDA (*Dicotyledons*).

By Mary Franklin Barrett. University of Florida Press, Gainesville. $8.50. xii + 414 pp.; ill. 1956.

The southern half of the Florida peninsula together with the Florida Keys provides a tropical or semi-tropical climate that can support a flora unknown to regions farther north. Some of these forms are native, while others have been brought in for ornamental or commercial purposes. Their strangeness to a visitor invariably raises the questions of name and origin, and it is for the purpose of providing answers that the present book has been written. Only the dicot species of trees are covered. Since the book serves both the initiated and uninitiated, a bit of leaf and flower morphology precedes a substantial key which is largely based on leaf characteristics. Each species is then described in some detail, although in a non-technical manner, together with leaf illustrations and information as to its origin and use. References are provided for those who would pursue the subject further, and the locations of many of the trees in and around Miami are given. The book should prove particularly interesting to the botanically minded native or tourist, although one may feel that the addition of some colored illustrations would have greatly enhanced the attractiveness and usefulness of the book.

C. P. SWANSON

PLANT TAXONOMY.

By Earl L. Core. Prentice-Hall, New York. $7.50. xiv + 459 pp.; ill. 1955.

Part I of this textbook deals with topics such as the history of taxonomy, the origin of species, evolution, plant geography, and morphology. Because of Core's ability to write, this part makes the book one of the most highly readable textbooks on taxonomy. If an occasional statement sounds a little too dogmatic, the professional botanist will recall that one of the marks of a good teacher in a beginning course is his ability to avoid including all the exceptions to the rule.

Part II consists primarily of descriptions and discussions of the families of vascular plants. 225 families of angiosperms are included. The sequence of families is of interest in reflecting the stage of present-day botany. Only two phylogenetic systems have been popular in America for three-quarters of a century—the Engler and Prantl system and the Besseyan system. The Besseyan system gained its widest use during the decade or so following the appearance of Pool's *Flowers and Flowering Plants*. In the 27 years since the first appearance of this book, botanical knowledge made it evident that many of the shortcomings of the Engler and Prantl system also afflict the Besseyan. Herbaria, understandably, and manuals are still arranged in accordance with the German system. The student finds himself very much in the position of one who, no matter how much he admires the metric system, had better be familiar with the Babylonian measuring system also. With good practicality, Core follows the Engler and Prantl system and hopefully awaits the day when an opus comparable to *Die natürlichen Pflanzenfamilien* will have a comparable impact on taxonomy.

GEORGE J. GOODMAN

LABORATORY EXERCISES ON THE PLANT KINGDOM.

By Paul C. Lemon and Norman H. Russell. Wm. C. Brown Company, Dubuque. $2.50 (paper). viii + 122 pp.; ill. 1954.

ECONOMIC BOTANY

SUPPLEMENT TO THE DICTIONARY OF GARDENING. *A Practical and Scientific Encyclopaedia of Horticulture. The Royal Horticultural Society.*

Edited by Patrick M. Synge; assisted by Specialists. Oxford University Press, London; [Oxford University Press, New York.] $10.00. xii + 334 pp.; ill. 1956.

Although this is a supplement to the 4-volume *Dictionary of Gardening*, it is nevertheless a valuable addition to any gardener's library in that the first part (135 pages) contains lists of recommended varieties of flowers, fruits, and vegetables for the British Isles. For those who lack the larger edition, these lists should provide a source of much information. In addition, a short section which deals with fertility rules in fruit planting should eliminate errors in varietal selections. Part II is concerned with corrections and additions to the 4-volume work, and while many of the short articles are of intrinsic interest, the material is necessarily sketchy and incomplete. Where no information is to be found on a particular gardening topic, reference must be made to the larger edition, which deals with

every plant suitable for outdoor or indoor culture in temperate climates.

C. P. SWANSON

MUSHROOM GROWING. *Bull. No. 34, Ministry of Agriculture and Fisheries.*

Her Majesty's Stationery Office, London; [British Information Services, New York]. 5s. (paper). iv + 79 pp. + 22 pl. 1954.

This is a brief, paper-backed volume written for the purpose of providing the basic information necessary to the successful culture of mushrooms. The beginner as well as the established grower can profit from its reading. Twenty-two plates provide visual aids which nicely complement the text.

DISEASES OF BRITISH GRASSES AND HERBAGE LEGUMES. *Second Edition.*

By Kathleen Sampson and J. H. Western. Cambridge University Press, New York. $3.00. xiv + 118 pp. + 9 pl.; text ill. 1954.

This report is an extensive survey of those diseases affecting grasses other than cereals, and those plants, particularly the legumes, used for forage purposes. Major attention is given to the diseases affecting seed production. A substantial bibliography adds materially to the usefulness of the volume to the plant pathologist, particularly since the European literature appears to be thoroughly covered.

SILAGE FERMENTATION.

By A. J. G. Barnett. Academic Press, New York; Butterworths Scientific Publications, London. $5.00. x + 208 pp.; ill. 1954.

This book is of interest primarily to agriculturists, both biological and chemical, since it is essentially a detailed consideration of silage fermentation as a basic biological problem. The methods of making silage and the chemistry of the reactions involved are dealt with, and a good background of biochemistry is necessary for a full appreciation of the discussions.

PLANT PHYSIOLOGY

MINERAL NUTRITION OF FRUIT CROPS. *Deciduous and Evergreen Tree and Small Fruits.*

Edited by Norman Franklin Childers; 27 contributors. Horticultural Publications, Rutgers University, New Brunswick. $10.00. xii + 907 pp.; ill. 1954.

The purpose of this rather large book is a consideration of the mineral nutrition of those plants yielding edible fruits of commercial value. The major emphasis is given to the tree and bush fruits, the only herbaceous species under discussion being the strawberry. The authors of the 18 chapters are scattered throughout the country so that various soil types and degrees of mineral deficiency are considered along with the problems which are peculiar to each type of fruit.

GENERAL AND SYSTEMATIC ZOOLOGY

TRAITÉ DE ZOOLOGIE. *Anatomie, Systématique, Biologie. Tome XVII, Fascicules I, II. Mammifères. Les Ordres: Anatomie, Éthologie, Systématique.*

Published under the direction of Pierre-P. Grassé. Masson & Cie., Paris. (I, II each) 11,800 fr. (cloth); 11,000 fr. (paper). (I) viii + 1170 pp., ill.; (II) viii + pp. 1171–2300 + 4 pl.; text ill. 1955.

This publication is probably the most important general work on mammals to have appeared in decades. I would venture the opinion that this series alone, unless it is later published in English, will make French virtually a required second language to the mammalogist.

The treatment begins with a short discussion of classification, followed by a presentation of the Mesozoic origin of the class. While the system of classification does not correspond exactly to any now in use, it is in general like that of Simpson, and is one that most mammalogists will readily accept. The remainder of the first part, and all of the second, is devoted to a compilation of information dealing with the systematics, natural history, and anatomy of the mammals in each of the various orders. The illustrations are profuse, and each section is terminated with an extensive bibliography. Although the subjects of reproduction and embryology are announced for a second volume yet to be published, a great deal on reproductive anatomy is included in this volume, as well as scattered bits of information on development.

It is inevitable that in a treatment of this magnitude some of the larger systematic groups should receive very short shrift, and in many genera, particularly among the rodents, only one or a few species receive any comment. The families, subfamilies, and genera are fully catalogued, however, and species are commented upon where they illustrate particular points of anatomy or behavior.

North American mammalogists may be a bit hypersensitive to the fact that the fauna of the western hemisphere is not always treated as fully as are areas of the old world. European mammalogists apparently are not as well supplied with the literature of American mammalogy as might be desired. For example, Hall's monograph on the American weasels is not even included in the bibliography of the Carnivora. American paleontology, on the other hand, receives full treatment.

This obviously stems from the fact that one cannot comprehend the over-all picture of mammalian evolution without including a survey of American fossils. This is not true of living mammals to the same degree, and the European workers seem to have concentrated upon their native hemisphere. This should make the series even more valuable to the American mammalogist, to whom most American publications are readily available, but to whom the vast literature of European writers is much less accessible. Here for his use is a virtual encyclopedia of knowledge, indexed and referenced to the *n*th degree, of the mammals of all those parts of the world which he very likely will never be fortunate enough to see.

It is unfortunate that the publishers have seen fit to put such a monumental work in such a cheap and unsubstantial binding. Quality deserves quality treatment.

BRYAN P. GLASS

MONOGRAPHIE DER OTOPLANIDAE (TURBELLARIA). *Morphologie und Systematik. Abhandl. Akad. Wissensch. Lit., Mainz, math. naturwiss. Kl., Jahrgang 1955, No. 13.*

By Peter Ax. Akademie der Wissenschaften und der Literatur, Mainz. DM 22.20 (paper). Pp. 499–796; ill. 1956.

Study of the benthonic microfauna of shallow waters along ocean coasts has been intensively pursued in recent years in Europe and has yielded a wealth of interesting forms among protozoans, turbellarians, gastrotrichs, archiannelids, crustaceans, and the like. The United States has lagged deplorably behind in studies of this type, but interest in this microfauna has been awakened, and already two new groups of crustaceans have been discovered. The present monograph is a splendid contribution to our knowledge of the microscopic animals of coastal waters. Of the 45 known species of the family, 27 are here described as new, and 16 new genera are added, making a total of 25. The monograph will furnish an indispensable guide for future workers on the family.

L. H. HYMAN

OPISTHOBRANCHIA OF SAGAMI BAY. *Collected by His Majesty The Emperor of Japan.*

Edited by Hirotaro Hattori; described, with an introduction by Kikutaro Baba; illustrated by Hiroo Sanada and Shiro Kato. Iwanami Shoten, Tokyo. viii + 194 + vii pp. + 50 pl.; text ill. 1949.

OPISTHOBRANCHIA OF SAGAMI BAY, SUPPLEMENT. *Collected by His Majesty The Emperor of Japan.*

Edited by Hirotaro Hattori; described by Kikutaro Baba; illustrated by Hatsuki Tsujimura and Taketo Ikebe. Iwanami Shoten, Tokyo. Yen 1800. vi + 59 pp. + 20 pl.; text ill. 1955.

It is rather surprising that one bay can furnish nearly 200 species and subspecies of nudibranchs, notable among gastropods for their fantastic shapes and brilliant colorings. The text, containing the taxonomic descriptions, illustrated with line drawings, is given in both Japanese and English and the colored plates, although perhaps somewhat dulled in reproduction, testify to the skill of the artists Hiroo Sanada and Shiro Kato, for the original work, and Hatsuki Tsujimura and Taketo Ikebe for the supplement. The two volumes constitute a major contribution to world knowledge of this group of gastropods.

L. H. HYMAN

THE BIOLOGY OF A MARINE COPEPOD, *Calanus finmarchicus (Gunnerus).*

By S. M. Marshall and A. P. Orr. Oliver & Boyd, Edinburgh and London. 21s. viii + 188 pp. + 18 pl.; text ill. 1955.

This book is a scholarly compilation of what has been published on the morphology, embryology, physiology, and ecology of the marine copepod, *Calanus finmarchicus*. Some original research work by the authors is included. Although taxonomy and distribution are not stressed, they are adequately discussed.

The authors have wisely chosen *Calanus finmarchicus* as a typical representative of a pelagic marine copepod. It is widely distributed over the world, has been the subject of much research, and is an extremely important link in the food chain of the oceans. It feeds on algae, bacteria, protozoa, etc., and in turn is eaten by many species of fish, some whales, and other carnivores.

The chapter on the food of copepods is particularly interesting. Putter's hypothesis, food selectivity, digestion, and efficiency of food usage in relation to its abundance are considered. Some as yet unanswered biological questions are mentioned. Perhaps the book will stimulate research to answer some of these.

The photographs, drawings, and tables for the most part are very good; however, the figures of the taxonomically important appendages should have been done in more detail. One seta is strangely omitted from Fig. 4c. Students of marine plankton and even those working on freshwater plankton will find this book very useful and interesting.

H. C. YEATMAN

MOSQUITOES OF NORTH AMERICA (*North of Mexico*).

By Stanley J. Carpenter and Walter J. LaCasse. University of California Press, Berkeley and Los Angeles. $10.00. viii + 360 pp. + 127 pl.; text ill. 1955.

Because of their economic and medical importance, a

great deal of work has been done on mosquitoes during and immediately after World War II. Many changes have been made in nomenclature; new species and subspecies have been described; others have been redescribed; and distribution records have been made more complete. This book is a thorough and authoritative revision of the mosquitoes in North America north of Mexico. In all, the authors recognize 143 species and subspecies, belonging to 11 genera. Each species is described according to the characters of the adult female, male, and larva. The descriptions are accompanied by exceptionally fine illustrations of the larvae and male terminalia, and at the end of the book there are 127 plates of the adult females. Although these are not in color, by skillful shading the artists have been able to show clearly the colorational pattern characteristics of the females. A list of synonyms, distribution records, and notes on biology are presented for each species. Keys are given to subfamilies, tribes, genera, and species.

The taxonomic sections are preceded by discussions on life history, collecting, preparation of specimens for study, and on external and internal anatomy. The morphological sections are supplemented with well-labeled illustrations. One apparent oversight is the failure to define or to indicate the location on the pleura of the "hypostigial spot." This spot is an important character in the key to adult *Aedes* females.

This is an excellent guide to the mosquitoes of North America, and will be a most useful reference work for every person whose work requires a knowledge of the identity, distribution, and habits of these insects.

LLOYD E. ROZEBOOM

LES ANOPHÈLES DE L'AFRIQUE DU NORD *et du Bassin Méditerranéen.*

By G. Senevet and L. Andarelli; preface by Edmond Sergent. Editions P. Lechevalier, Paris. 3,000 fr. (paper). 280 pp.; ill. No date.

This is a taxonomic revision of the *Anopheles* mosquitoes of the Mediterranean region and North Africa. In Part I there is a description of the general morphology of the adult female, male, larva, pupa, and egg. In Part II descriptions are given of the adult, male terminalia, larva, pupa, and egg of the 18 species recognized by the authors. In addition there are discussions on subspecific populations, which are referred to as races, and on biology. The authors do not recognize the specific status of certain of the populations belonging to the *A. maculipennis* group, but consider them all to be races. Some of these "races" are subdivided into "subraces." The basis for recognition of such categories is entirely morphological. The biological summaries include distribution records; notes on breeding places, flight, and resting habits; host preferences; and importance as disease vectors.

Part III, four chapters, lists distribution records, and presents keys to species of adults, male terminalia, larvae, pupae, and eggs. The keys and descriptions are supplemented by 62 figures. Although some taxonomists may not agree with the interpretations of certain characters by which populations are recognized as races, this monograph should be a useful guide to the anophelines of the Mediterranean and North African regions.

LLOYD E. ROZEBOOM

THE MOSQUITOES OF ARABIA. I. *Bull. Brit. Mus. (nat. Hist.), Entomol., Vol. 4, No. 3.*

By P. F. Mattingly and K. L. Knight. British Museum (Natural History), London. 15s. (paper). Pp. 89–141; ill. 1956.

THE HONEY-GUIDES. *Bull. U. S. nat. Mus., No. 208. By Herbert Friedmann. Smithsonian Institution, Washington.* $1.75 (paper). xii + 292 pp.; ill. 1955.

The fascinating tropical Old World honey-guides (Indicatonidae) were only a few years ago one of the least known families of birds as far as habits are concerned. Now, thanks to Friedmann's efforts, they are rapidly becoming very well known. Two of the eleven species live in the East Indies, the other nine in Africa. Although nowhere a dominant element of the fauna, the honey-guides are remarkable for three habits, displayed by some or all the members of the family, their brood parasitism (in the fashion of cuckoos), their "guiding," and their ability to digest wax. Friedmann reports in detail all that he has been able to find out about these three characteristics. Brood parasitism seems universal in the family, barbets, woodpeckers, and other hole-nesting birds being the most frequent victims of the genus *Indicator*. The parasitism seems phylogenetically old, and at least one special adaptation connected with it has evolved. The newly hatched chicks of several species of honey-guides have a pair of bill hooks with the help of which they evict their nest mates—the details of this action are not yet known. In the American cowbirds, a much more recent group of nest parasites, no such special adaptations have yet evolved.

While brood parasitism is known in five other families of birds, "guiding" to bees' nests is unique. It consists in the bird excitedly uttering a churring call, and if the observer follows, in flying ahead of him, waiting after every few trees, and continuously calling, until the observer has approached the bird within 15 to 50 feet. When the bees' nest is reached, the honey-guide watches quietly on a nearby branch until the honey has been taken out. At the end the honey-guide comes down to feed on the bits of comb strewn around. Friedmann gives a number of accounts of eye witnesses and much

detail about variation in the guiding habit. The honey badger or ratel was apparently the original "recipient" of the guiding behavior before it was transferred to man.

The wax-eating habit of the honey-guides is likewise unique among vertebrates. It is now well established that the birds are not particularly interested in the bee larvae, as was formerly believed, but rather in the bees' wax. Indeed there is a record, nearly 400 years old, of honey-guides eating wax candles in a mission church in Portuguese East Africa. Friedmann, in work subsequently published, has found that microorganisms in the birds' intestines produce the enzymes which permit digestion of this strange food.

These are merely a few glimpses at the contents of this monograph. In addition to a general account of the evolution, classification, and biology of the family, Friedmann also presents a detailed summary of what is known of each individual species. The habits in some of the genera deviate considerably from those of *Indicator*, as described above. This fascinating group of birds well deserves the loving attention which Friedmann has given it.

ERNST MAYR

THE EUPHAUSIACEA (CRUSTACEA) OF THE NORTH PACIFIC. *Bull. Scripps Inst. Oceanogr. Univ. Calif., Vol. 6, No. 8.*

By Brian P. Boden, Martin W. Johnson, and Edward Brinton. University of California Press, Berkeley and Los Angeles. $1.50 (paper). iv + pp. 287–400; ill. 1955.

The euphausiids are gradually becoming one of the best known crustacean groups from a taxonomic point of view. This report, based on extensive collections gathered within 500 miles of the Pacific coasts of the United States and Lower California, as well as on less abundant material from other parts of the Equatorial and North Pacific, adequately fills one of the few remaining gaps in our knowledge of the distribution of this small but very important group. No less than 51 (55 is erroneously mentioned once in the introductory remarks), or more than half of the known species, and all but one of the 11 recognized genera are represented in these collections. The keys to the genera and species, and the excellent figures of each of the species, make the report a most useful tool for the carcinologist and oceanic biologist.

The headings of the species keys unfortunately do not indicate that they are limited to the species covered by the report, a failing all too often to be noticed in restricted monographic treatments of this kind. Also, no explanation is given for omitting the depth ranges for four of the species. Some may regret the lack of documentation of the specimens from which the figures were made, especially because the authors imply that certain of them were based on South African material, but this objection is less important than it would be if euphausiid nomenclature was less stable than it is. These minor exceptions merely offer the reviewer an opportunity to exercise his prerogative. If all systematic papers were as immune from criticism as this one, biological science in general would be farther advanced than it is today.

FENNER A. CHACE, JR.

THE LARVAL TROMBICULID MITES OF CALIFORNIA (*Acarina: Trombiculidae*). *Univ. Calif. Pub. Entom., Vol. 11, No. 1.*

By Douglas J. Gould. University of California Press, Berkeley and Los Angeles. $2.00 (paper). iv + 115 pp.; ill. 1956.

BRITISH MITES OF THE SUBFAMILY MACROCHELINAE TRÄGÅRDH (*GAMASINA*-MACROCHELIDAE). *Bull. Brit. Mus. (nat. Hist.), Zool., Vol. 4, No. 1.*

By G. Owen Evans and E. Browning. British Museum (Natural History), London. 17s.6d. (paper). Pp. 1–55 + 4 pl.; text ill. 1956.

Both Gould, and Evans and Browning, have done a service by describing, figuring, and providing keys for the identification of a restricted group of mites from a restricted area. Their descriptions, figures, and keys are uniformly excellent. Both papers provide an excellent bibliography, and the usefulness of Gould's paper is greatly enhanced by an index. Gould reports 56 species of trombiculids from California and describes 15 of them as new. The paper follows the most recent classification for trombiculids, and the descriptions and figures are based on current practice in the field.

Evans and Browning include 23 species of macrochelids, of which 3 species are new. They have also established new standards for describing and figuring macrochelids, and have revised the classification. Their work adds another group of mites to the rapidly increasing number of families and subfamilies that are sufficiently well studied to be recognized from their descriptions. Evans and Browning's emphasis on chaetotaxy in their descriptions and classifications is an outstanding advance. The authors are also to be congratulated for their inclusion of excellent photomicrographs.

G. W. WHARTON

THE EVOLUTION AND TAXONOMY OF THE SARCOPHAGINAE (*Diptera, Sarcophagidae*). *Ill. Biol. Monographs: Vol. XXIII, Nos. 3–4.*

By Selwyn S. Roback. The University of Illinois Press, Urbana. $5.00 (cloth); $4.00 (paper). vi + 181 + iv pp.; ill. 1954.

A careful and well-illustrated monograph on the chief subfamily of the Sarcophagidae, or flesh-flies. There

are about 1200 known species in this family, with habits varying from active parasitism to feeding on dung or decaying vegetable matter. This work attempts to discover the phylogenies of the genera within the subfamily Sarcophaginae and to base a taxonomic classification upon those phylogenies. The male aedeagus is regarded as the critical structure in tracing these relationships. 145 species, mostly Nearctic, were studied, and 224 additional species were placed taxonomically on the basis of published descriptions: 130 more species, poorly described, are put in tentative positions.

A Revision of the Flies of the Genus *Rivellia* (Otitidae, Diptera) of America North of Mexico. *Proc. U. S. nat. Mus., Vol. 106. No. 3363.*

By Ryoji Namba. Smithsonian Institution, Washington. Free upon request (paper). Pp. 21–84; ill. 1956.

Type Species of the Genera and Subgenera of Parasitic Wasps Comprising the Superfamily Proctotrupoidea (Order Hymenoptera). *Proc. U. S. nat. Mus., Vol. 105. No. 3359.*

By C. F. W. Muesebeck and Luella M. Walkley. Smithsonian Institution, Washington. Free upon request (paper). Pp. 319–419. 1956.

This admirable work provides an indexed catalog of 735 generic and subgeneric names, for the most part published before 1954, used within the families ordinarily grouped as proctotrupoids, and including as well those of the Aulacidae, Gasteruptiidae, and Evaniidae. Five new names are proposed.

K. W. Cooper

Bryozoa of the United States Navy's 1947–1948 Antarctic Expedition, I–IV. *Proc. U. S. nat. Mus., Vol. 105. No. 3358.*

By Mary D. Rogick. Smithsonian Institution, Washington. Free upon request (paper). Pp. 221–317 + 35 pl. 1956.

These are the first of a planned series of studies on the considerable collection of bryozoans made by the U. S. Navy in the Antarctic. They will be of interest not only to workers on the Bryozoa but also to those interested in the antarctic fauna. The author's talent for illustration is well known, and the illustrations of the present studies exemplify her high standard of excellence in this regard.

L. H. Hyman

Birds Collected by Mr. F. Shaw-Mayer in the Central Highlands of New Guinea 1950–1951. *Bull. Brit. Mus. (nat. Hist.), Zool., Vol. 3, No. 10.*

By R. W. Sims. British Museum (Natural History) London. 15s. (paper). Pp. 387–438 + 2 pl.; text ill. 1956.

Frogs of Southeastern Brazil. *Bull. U. S. nat. Mus., No. 206.*

By Doris M. Cochran. Smithsonian Institution, Washington. $2.00 (paper). xvi + 423 pp. + 35 pl.; text ill. 1954 [1955].

The amphibian fauna of tropical America is rich and varied. Its literature is widely scattered and, with but few exceptions, consists of observational accounts and restricted systematic studies. There are compilatory faunal accounts but real synthetic studies are rare. Cochran's *Frogs of Southeastern Brazil* is a big step forward toward such a synthesis. This report is in the classic tradition. Herpetological bulletins from the pens of curators in the National Museum have been enriching the literature for over half a century.

The present work is a comprehensive and technical review of 135 species and subspecies of frogs distributed among six families. Descriptions are remarkably complete. Quantitative information is presented as percentages of total length (both in tabular fashion and graphically) rather than in the form of raw data. When measurements are given, they are mean values for a series if more than one specimen has been studied. These methods are space-saving and quite sufficient for providing an average picture of the quantitative characters measured. However, to a subsequent student interested, for example, in ontogenetic growth, the raw data would have been more useful.

There is an extensive bibliography, a number of photographs of both living and preserved specimens, some excellent figures drawn by Doris Cochran herself, and an index to scientific names. *Frogs of Southeastern Brazil* will be a standard descriptive work for a long time.

It is worth mentioning that this *Bulletin* is enlivened by a modernized and attractive cover in mauve and gray. It is a great improvement over the formal and old-fashioned black and olive-drab covers of earlier *Bulletins* and *Proceedings*.

Arnold B. Grobman

Primates, *Comparative Anatomy and Taxonomy. II. Haplorhini: Tarsioidea. A Monograph.*

By W. C. Osman Hill. Thomas Nelson & Sons, Edinburgh. 63s. xx + 347 pp. + 14 pl. + 1 folded table; text ill. 1955.

This is Part II of Hill's projected monograph of the

Primates, which the publishers state will run to seven or eight volumes, and which will thus be by far the most voluminous publication on a single order of mammals ever undertaken. In view of the 40 years that separated the present review from Elliott's earlier *Review of the Primates*, it is extraordinary that another four-volume *Handbuch der Primatenkunde* has just been announced from Switzerland.

The first 103 pages are devoted to a general review of the morphology, reproductive physiology, behavior, and mental development of the Haplorhini, which in Hill's classification includes all primates except the lemurs and their relatives. An adequate summary of the vast primate literature in so few pages would be difficult, but not impossible. It is tragic that Hill's treatment is so superficial, uncritical, and verbose that it is almost worthless. Even where critical summaries already exist he has not used them: the excellent data of Schultz and Straus on vertebral formulae in the primates are reduced to absurdities such as "thoracic vertebrae vary from 11 to 15, but seldom exceed 14." Such emasculation of data reflects a total failure on the part of the author to appreciate the nature of scientific data. The rambling and generally incoherent discussion of placentation ignores Mossman's important monographic summary, of which the author was apparently unaware.

The remainder of the volume deals with living tarsiers (130 pages) and fossil tarsioids (74 pages). The anatomy, reproductive physiology, behavior, and taxonomy of *Tarsius* are reviewed and illustrated. Hill recognizes 3 species of living tarsiers: *T. syrichta* from the Philippines, *T. bancanus* from the Malayan subregion, and *T. spectrum* from Celebes, each with several subspecies. Few would quarrel with this view, although I fail to find some of Hill's "characters" in the large series of Philippine and Bornean tarsiers at my disposal. As in Volume I of this series, numerical data, where given, are presented in raw form, without even the most elementary statistical treatment. I continue to believe that this is fantastic in the middle of the twentieth century. There is a bibliography of 20 pages, and an index. The physical appearance of the volume is a credit to the publishers.

D. Dwight Davis

ECONOMIC ZOOLOGY

Principles of Veterinary Science. *Fifth Edition.* *By Frederick Brown Hadley. W. B. Saunders Company, Philadelphia and London.* $5.25. xii + 546 pp.; ill. 1954.

The present edition, like its predecessors, is designed for agricultural students and livestockmen rather than for the professional veterinarian. The book, therefore, deals with veterinary science rather than with veterinary medicine, and is more concerned with the practical aspects of the health of livestock than with the theoretical implications. Having served as a standard textbook for the past 35 years, the book needs no further introduction.

An Outline of the Infectious Diseases of Poultry. *By Frank H. Mosley. Burgess Publishing Company, Minneapolis.* $2.25 (paper). viii + 83 pp. 1954.

The Bacteriology of Commercial Poultry Processing.

By *M. F. Gunderson, H. W. McFadden, and T. S. Kyle. Burgess Publishing Company, Minneapolis.* $3.00 (paper). xiv + 98 pp.; ill. 1954.

The first of these two manuals is a listing of the various diseases which infect poultry, and is a part of the lecture course given to veterinary students at the Alabama Polytechnic Institute. Each disease is broken down into the following subcategories for convenient handling: definition, synonyms, history and distribution, etiology, symptoms, pathology, diagnosis, immunity, and control and eradication. The second manual is a report of the factors influencing the quality of processed poultry by the time it reaches the consumer. It is a comprehensive treatment and investigation of all phases of poultry handling, and makes it apparent that the poultry industry is now providing the public with a good product, but one that under certain circumstances could be bettered. The recommendations of the authors are clearly stated and should result in an improved quality of product.

Standard Laboratory Colonies of Termites for Evaluating the Resistance of Timber, Timber Preservatives, and Other Materials to Termite Attack. *Bull. No. 277.*

By F. J. Gay, T. Greaves, F. G. Holdaway, and A. H. Wetherly. Commonwealth Scientific and Industrial Research Organization, Melbourne. Free upon request (paper). 60 pp. + 4 pl.; text ill. 1955.

Fish Handling and Hold Construction in Canadian North Atlantic Trawlers. *Bull. No. 103.*

By W. A. MacCallum. Fisheries Research Board of Canada, Ottawa. 65 cents (paper). viii + 61 pp.; ill. 1955.

ANIMAL MORPHOLOGY

The Vertebrate Body. *Second Edition.*

By Alfred Sherwood Romer. W. B. Saunders Company, Philadelphia and London. $7.00. viii + 644 pp.; ill. 1955.

The new edition of this excellent truly modern textbook should be received with enthusiasm equal to that which greeted its first appearance in 1949 (*Q.R.B.* 25: 95. 1950). The author states that he has made some two thousand minor textual changes. In addition, a number of short sections have been rewritten. The material on limb muscles has been somewhat shortened, and a revised geological table has been contributed by Dr. H. E. Wood.

EVELYN HOWARD

MICROSCOPIC ANATOMY OF THE DIGESTIVE SYSTEM OF THE CHICKEN.

By M. Lois Calhoun. Iowa State College Press, Ames. $3.50. x + 108 pp.; ill. 1954.

This revised reprint of a Ph.D thesis, originally published in the *Iowa State College Journal of Science* 7: 261–382 (1933), is in response to a continuing demand which an inspection of the bulletin makes easy to understand. The text includes a straight-forward review of the literature and a description of the author's own researches on the microscopic anatomy, beginning with the beak and ending with the bursa cloacae, yolk sac, and yolk stalk. The discussion is brief. There is a very extensive list of references, but unfortunately no index. (However, perhaps one is really unnecessary in so relatively brief and consecutively organized an anatomical work.) The outstanding feature of the bulletin is unquestionably its very excellent, well-reproduced illustrations, some of which are superb photographs of the gross anatomy of various parts but the majority of which are halftones of sectioned histological material. The quality of the paper is adequate to permit a really good rendition of details.

CAT MUSCULATURE.

By Gordon M. Greenblatt. The University of Chicago Press, Chicago. $1.00 (paper). 32 pp.; ill. 1954.

ATLAS AND DISSECTION GUIDE FOR THE STUDY OF THE ANATOMY OF DOMESTIC ANIMALS. *Third Edition.*

By H. L. Foust and Robert Getty. Iowa State College Press, Ames. $4.50. 105 pp.; ill. 1954.

The organization of this guide has been quite extensively changed from the second edition (*Q. R. B.* 25: 342. 1950). There are 46 beautiful plates, mostly of dissections of the dog, horse, and cow, with a few representing cat, chicken, and pig. Part One contains directions for the Dissection of the Dog, as being the most useful example for the study of the anatomy of domestic animals; Part Two contains the Directions for Dissection of Large Animals. Extensive lists of references add to the value of the text. The pages are now numbered and there is a table of contents for the illustrations as well as the text. A number of the drawings are new.

THE STRUCTURE AND FUNCTION OF SKIN.

By William Montagna. Academic Press, New York. $8.80. xviii + 356 pp.; ill. 1956.

This is a detailed, comprehensive treatment of the anatomy of skin discussed from a physiologic point of view. It should join Stephen Rothman's *Physiology and Biochemistry of the Skin* as a modern classic in the scientific basis of dermatology.

VICTOR A. MCKUSICK

CARDIAC ANOMALIES. *A Clinicopathologic Correlation. By Vincent Moragues and Chester P. Lynxwiler. The Williams & Wilkins Company, Baltimore.* $6.50. x + 92 pp.; ill. 1954.

Pictures and extensive notes of malpositions of the heart, defects of the cardiac septa, valvular anomalies, anomalies of septation of the truncus arteriosus, transposition complexes, anomalies of the aortic arch, and Ebstein's malformation of the tricuspid valve. The notes cover the pathology, course of the circulation, clinical features, electrocardiography, radiological studies, laboratory data, prognosis, and treatment. The pictures include not only dissections but also radiograms, electrocardiograms, and occasionally sectioned material.

ANIMAL GROWTH AND DEVELOPMENT

DEVELOPMENT AND DIFFERENTIATION. *Biochemistry, Physiology, Methodology. Experimental Cell Research, Suppl. 3, 1955. Presented to John Runnström. Committee on Arrangements, T. Caspersson, G. Ehrensvard, T. Gustafson, S. Hörstadius, P. E. Lindahl, and O. Lindberg. Academic Press, New York.* $8.00 (paper). viii + 416 pp. + 1 pl.; text ill. 1955.

This special issue of *Experimental Cell Research* is dedicated to Professor John Runnström, who, at the age of 67, has retired from his positions as Professor of Experimental Cytology and Cell Research at the University of Stockholm and as Director of the Wenner-Gren Institute for Experimental Biology. Seventy-three authors have contributed 41 articles which embrace a variety of topics in biochemistry, cytology, and embryology. It is appropriate that several articles deal with the mechanisms of fertilization and differentiation, areas of research in which Professor Runnström has

carried on pioneering and significant investigations. A number of the experiments described were, in fact, suggested either by him personally or by his earlier discoveries. It is not practical to review the separate contributions; collectively, their quality is high, as is fitting in a volume dedicated to John Runnström, whose indefatigable efforts to penetrate the mechanisms of development not only have resulted in notable individual achievements, but also have been a remarkable stimulus to the research of others.

The volume, which is paper-bound, is well printed; an adequate index is included. My only objection is to the price; eight dollars seems a lot to ask.

JAMES D. EBERT

PRINCIPLES OF EMBRYOLOGY.

By C. H. Waddington. The Macmillan Company, New York. $7.50. x + 510 pp.; ill. 1956.

The publication of Waddington's *Principles of Embryology* represents an event of the first importance for those who attempt to present to students an accurate description of the modern corpus of embryological knowledge, and to imbue them with a desire for forming critical embryological judgments.

The book is divided into two principal parts. The first, *The Facts of Development*, includes an introductory chapter on the character of embryological science, three chapters dealing with the gametes, fertilization and cleavage, followed by three which cover in turn the development of echinoderms, of forms with spirally cleaving eggs, and of ascidians and Amphioxus. The four ensuing chapters devote themselves to vertebrates: two, to the development of amphibians and birds through gastrulation and the establishment of the embryonic axis; one, to embryo-formation in other vertebrates. The next, a chapter on organ development in vertebrates, less cohesive and critical than the rest of the book, is the only weak portion of it. This first part of the book concludes with two succinct but clear chapters on selected aspects of growth and of regeneration. The bulk of the second part of the book, *The Fundamental Mechanisms of Development*, consists of four chapters which deal excellently with the relationships of cellular constitutents, particularly the genes, to development. Then follows a chapter which formulates briefly a modest but eminently sensible general theory of differentiation, and finally one on individuation as the formation of pattern and shape.

The book is addressed to students who are presumed to have some slight acquaintance with embryology; and in its preface, the author almost apologizes for having minimized emphasis on the descriptive aspects of embryology in favor of the experimental. He need have no misgivings; he has included more than enough descriptive material to permit his readers to understand the experimental work discussed. It is, after all, only in the light of the experimental lamp that the contours of the morphogenetic data derived from descriptive study assume their full perspective.

The division of the text into the two sections purporting to deal with facts as opposed to mechanisms is not, however, as strictly clear-cut as the physical appearance of the outline in the table of contents might suggest. It is, as a matter of fact, of advantage to the argument that the facts concerning genetic control are pretty well localized in the second, not the first, part of the book; and in the first portion, many processes which might be considered epigenetic mechanisms are fairly exhaustively discussed. Embryologists who are already acquainted with the ideas of Waddington will remember his predilection for the concept of canalization which implies a choice of alternatives. Treatment of facts in embryology is not an alternative to consideration of mechanisms; they are too complexly interrelated, and it is a strength of the volume that the organization of the material, if not the table of contents, recognizes this.

Waddington tends sometimes to the canalization of his judgments in other respects. He continues to make a strong case for a distinction between individuation and evocation. Many embryologists may still dispute this interpretation, and wonder to what degree the dichotomy characterizes the embryo, and to what the investigator's mind. And there will be others of his interpretations in which not all embryologists will concur. He has twice, for instance, stated or implied that the development of the chick is more complex than that of the amphibian. Is the development of the chick in its essence more complex than that of the amphibian, or does it only seem so because of the imperfections of the scientist's hand or intellect? It is interesting to compare, in this connection, the title of Waddington's book, *Principles of Embryology*, with that of one of the best of its predecessors, Weiss' *Principles of Development*. Do the principles reside in the workings of the embryo or in the operations of the embryologist's mind?

Be that as it may, one of the very great excellences of this volume lies in the fact that where his own point of view is expressed by the author, he almost invariably devotes considerable space to the opinions of investigators who may differ with him. This characteristic of the book, which recurs over and over again, is of course of high value to the teacher who wishes to encourage his students to think critically. But it is also of great advantage for more advanced readers, who on this account will find the book exceptionally stimulating. Waddington writes with the pen of an angel, and like the angels what he composes is no lullaby.

Perhaps, however, as great a virtue of his book is its optimism. While in a vast number of cases the author presents divergent interpretations, and thus indicates what is unknown as well as what is known, he nonetheless spares himself the defeatist mood that has recently

colored the thought of a number of individuals who are currently engaged in the teaching of embryology. The student who reads *Principles of Embryology* will gain from it, besides great pleasure in the acquisition of facts accurately and clearly presented, and of balanced judgment with respect to their interpretation, a firm and hopeful conviction that experimental and genetic embryology have made great accomplishments and will continue to make greater ones. We are enormously in Waddington's debt for having available a book of this character, which is recommended in the strongest possible terms for the use of college and university students, graduate and undergraduate, of embryology.

JANE OPPENHEIMER

LABORATORY MANUAL OF VERTEBRATE EMBRYOLOGY. *By Roberts Rugh. Burgess Publishing Company, Minneapolis.* $3.00 (paper). xi + 250 pp.; ill. 1956.

LABORATORY STUDIES OF CHICK AND PIG EMBRYOS. *By Ray L. Watterson. Burgess Publishing Company, Minneapolis.* $2.25 (paper). iv + 64 pp.; ill. 1955.

VETERINARY HISTOLOGY AND EMBRYOLOGY. (*Lecture Outlines and Laboratory Guide*). *Fourth Edition. By Harry L. Foust and Robert Getty. Burgess Publishing Company, Minneapolis.* $5.00 (paper). ix + 351 pp.; ill. 1955.

The new edition of Rugh's popular manual is very little changed from the previous one. The description of amphioxus development has been lengthened, new photographs on whitefish cleavage and frog gametes have been added, there are more blank pages for drawing chick whole mounts whereas space for drawing the cross-sections of the 33-hour chick has been omitted, and the typography has been very greatly improved. Somehow the term *Anlage* (*anlage* as in the earlier editions is generally accepted) has been revised to *anlagé*; the confusion might be easily avoided by using the word *rudiment* from the beginning. Inasmuch as he has provided us with one of the most complete and generally useful laboratory guides for embryology, it is somewhat discouraging to note that Rugh has not taken advantage of the opportunity to do more extensive revision of his text: e.g., of the criticisms made of the last edition (see *Q. R. B.* 24: 251, 1949) only the least serious one has led to a modification, the disputed question now being "What is a zygote?" (p. 15). Shortcomings remain in the glossary, for instance, the definition of a *field*—"mosaic of spatio-temporal activities within the developing organism." And the grossly inaccurate sagittal section of the 21-day human embryo (p. 207) taken from von Spee, 1889, might best be labelled as a historical curiosity or else replaced. Aside from difficulties such as these, however, the manual will remain attractive to many instructors because of its broad coverage and numerous illustrations.

Watterson's guide, on the other hand, treats only a restricted portion of the usual laboratory work in embryology and would presumably have to be supplemented by the instructor for use in a semester course. He provides very detailed directions for studying whole mounts and serial cross sections of the 33-, 48- and 72-hour chick, and cross sections of the 10 mm. pig. Following the 33- hour exercise, there are five pages describing the essential developmental changes preceding this stage; in addition, brief mention is made at the appropriate places of demonstrations of living chick embryos of 48 and 72 hours of incubation. There are only three illustrations, but the text very frequently directs the student to inspect pictures in the standard textbooks. The novelty of this manual lies in the provision for the making of simple graphic reconstructions by the student as an aid to his interpretation of serial cross sections in three dimensions. In the case of the 33-hour chick, for example, the number of the section in which each important structure begins or ends is to be placed as a dot on a graph in which section numbers run down the vertical axis and the names of the structures, arranged in groups according to germ layer of origin, are placed along the horizontal. Finally, the pair of dots marking the anterior and posterior limit of each structure is interconnected with a line in the usual germ-layer color convention, thus visualizing the parts of the embryo in the long dimension. Reconstructions of the older chicks and the pig embryo are slightly more elaborate. Although it can hardly be doubted that this manual will leave the student proficient in visualizing serial cross sections and thoroughly aquainted with the anatomical details of the stages covered, the reviewer questions the advisability of concentrating on this aspect of embryology to such an extent that the student has almost no chance to make any of his own anatomical preparations, or to see for himself the more dynamic features of the embryo which give the study of development its characteristic vitality and interest.

Foust and Getty devote only three of twenty-one laboratory exercises to embryology (starfish, chick, pig and fetal membranes), and also give much space to outlines to be filled in by the student during lectures, so that their manual is not strictly comparable with either of the above. The remaining exercises deal with (a) various aspects of cytology, (b) connective, muscular and nervous tissues, (c) nervous vascular, digestive, respiratory and urogenital systems, and (d) endocrine glands, integument, eye and ear. Each slide is to be studied with the aid of only a series of questions and, frequently, drawings to be labelled. The drawings altogether take up approximately thirty-four pages and are generally very good. There are also many references, apparently brought up to date wherever the subject permitted. Although it is less evident in the laboratory work than in the lecture outlines (which would seem to

be a poor pedagogical aid), one of the best features of the manual is its attempt to integrate embryology and histology into a single course.

T. SIPPEL

SYMPOSIUM ON PROBLEMS OF GERONTOLOGY. *Proceedings of a Symposium held under the auspices of The Johns Hopkins University School of Hygiene and Public Health, and The National Vitamin Foundation, New York City, March 2, 1954. Nutrition Symposium Series, No. 9.*

By F. H. Bethell, B. F. Chow, C. S. Davidson, H. J. Deuel, Jr., D. J. Ingle, J. E. Kirk, A. I. Lansing, C. N. H. Long, H. A. Rafsky, and N. W. Shock. The National Vitamin Foundation, New York. $2.50 (paper). ii + 142 pp.; ill. 1954.

This symposium presents a collection of 10 brief papers summarizing work already published elsewhere. No general discussion is included, and the coherence of the contents is minimal. The contents are as follows: Some Physiological and Biochemical Aspects of Aging (N. W. Shock); Senescence as a Sequel to Adolescence (A. I. Lansing); Fat Metabolism—with special reference to Problems of Aging (H. J. Deuel, Jr.); Protein Metabolism—with particular reference to Problems of Aging (C. S. Davidson); Vitamin B_{12} and Aging (B. F. Chow); Blood and Urine Levels in the Aged (J. E. Kirk); Hemopoietic Factors with Reference to Aging (F. H. Bethell); The Hormones and Metabolism (C. N. H. Long); Endocrine Stress and Aging (D. J. Ingle); and Special Nutritional Problems of the Aged (H. A. Rafsky).

What is needed to pull such a variety of material together and to develop some general views in regard to the biological nature of aging has since the publication of this symposium been supplied by Alex Comfort in his recent book, *The Biology of Aging.*

BENTLEY GLASS

PROBLEMS OF AGING. *Transactions of the Fifteenth Conference, January 20, 21, and 22, 1953, Princeton, N. J.*

Edited by Nathan W. Shock. Josiah Macy, Jr. Foundation, New York. $4.25. 213 pp.; ill. 1954.

This final Macy Conference on Aging centered around presentations of four main topics: Cellular Structure (Warren Andrews); Biochemical Studies on the Process of Aging (Bacon Chow); The Role of Comparative Physiology in Studies of Aging (F. Bourlière); and a retrospective look at the Macy Foundation's interest in aging over a 17-year span (Clive M. McCay). The Medical Director, 12 members, and 7 guests actively discussed the subjects which were introduced and a good many that were tangential. Although the thread may occasionally become lost, a sufficient body of interesting evidence is presented here within so few pages as to offer a good introduction to problems of aging for those unacquainted with the field. The inclusion of a cumulative index to the entire series of conferences on aging is a most commendable feature.

BENTLEY GLASS

ANIMAL PHYSIOLOGY

THE PHYSIOLOGY OF DIAPAUSE IN ARTHROPODS.

By A. D. Lees. Cambridge University Press, New York. $2.50. x + 151 pp.; ill. 1955.

In this fourth monograph of the Cambridge Experimental Biology series, A. D. Lees, who is well qualified by his extensive investigations of diapause in red spider mites, presents a lucid review of diapause, a phenomenon which constitutes one of the important means of adjusting the life cycles of animals and plants to the passage of events in their inconstant environment. This temporary lagging of growth or reproduction, which is diapause, has probably attained its greatest diversity of expression among the arthropods although it is by no means unknown even among mammals. As far as arthropods are concerned, the diapause of insects and mites seems to have been the most extensively studied, perhaps a consequence of the economic impetus of pest control. This, of course, is not to imply that the results of investigations of diapause are only of interest to economic zoologists. Rather, as shown by the author, they are of real significance in other fields, particularly in developmental physiology and insect endocrinology.

If insect dormant and active periods are to be synchronized with critical phases of the environment, be they progression of seasons or growth processes of a host organism, dependable cues are required. The most common signal for free-living insects appears to be the photoperiod. Discussion of this important topic occupies the bulk of an early chapter from which we learn immediately that the fundamental questions are largely unanswered, despite the intensive experimentation which has already been devoted to photoperiodism. Only the crudest experimental approaches have been made toward comprehension of the underlying mechanisms of the diapause reaction to light cycles. In most instances even the gross anatomical site of photoactivation remains unknown, not to mention biochemical loci. It does at least appear that the receptors concerned in insect photoperiod responses are unlike those of plants, for the action spectra of photoactivation in plants and insects appear to be quite different.

The discussion proceeds from photoperiodism to another group of diapause regulative signals which are, as a matter of fact, more like barriers to development.

A classic example is the dependence of certain grasshopper embryos upon water to terminate diapause. Cold is another obvious example. Still another diapause regulating system has great potential significance to our understanding of insect endocrine processes. In this instance, the system consists of mechanisms synchronizing parasite development with the growth of its host. Among the most interesting of these cases of host-parasite synchrony are ones in which the parasite is able to terminate diapause in its host. Here are natural experiments, as yet unexploited, which may be worthy approaches to the mysteries of the endocrine systems of insects.

In his analysis of diapause metabolism, Lees reemphasises for us the fundamental metabolic characteristic of diapause, that is, segregation of the ordinarily intertwined processes of growth and maintenance. He observes that this segregation is of major significance to survival, for it results in conservation of limited metabolic reserves during the sometimes protracted period of quiescence. Moreover, it is this aspect of diapause which promises much to the developmental physiologist who, as perhaps with no other group of animals, may so precisely differentiate developmental processes and the substratum of maintenance metabolism in diapausing insects.

Thus we find diapause to be a phenomenon whose study requires cutting across many disciplinary boundaries, and whose pursuit has rewarded us with novel and useful approaches to a myriad of difficult problems ranging from the biochemical to the ecological. One may confidently expect the appearance of Lees' monograph, as it stimulates the interest of investigators in related fields, to induce further advances in the physiology of diapause itself, as well as in those subjects for which diapausing insects are uniquely favorable experimental material.

JAMES F. CASE

TEXTBOOK OF MEDICAL PHYSIOLOGY.

By Arthur C. Guyton. W. B. Saunders Company, Philadelphia and London. $13.50. xiv + 1030 pp.; ill. 1956.

PRINCIPLES OF HUMAN PHYSIOLOGY. *Twelfth Edition. By Sir Charles Lovatt Evans; with chapters on the special senses by H. Hartridge; orginally written by E. H. Starling. Lea & Febiger, Philadelphia.* $12.50. xii + 1233 pp. + 6 pl.; text ill. 1956.

Both of these textbooks profit and suffer from the effects of single authorship. Guyton's book, as a first edition, does not have the advantage of having inaccuracies pointed out as they must have been in the course of the nine revisions by Evans since he took over Starling's *Physiology* in 1928. On the other hand, Guyton has been able to write his book completely *de novo*, with the result that it is in general more readable and does not carry the useless baggage a reviser might be reluctant to relinquish.

Guyton's book will probably appeal mainly to students. Evans' edition of Starling will probably prove cumbersome to beginning students, but for advanced students, instructors, and researchers will be useful. It is likely that others of the existing textbooks still better satisfy the requirements of all groups.

VICTOR A. MCKUSICK

THE PHYSIOLOGY OF DOMESTIC ANIMALS. *Seventh Edition.*

By H. H. Dukes; with a chapter on Physicochemical Basis of Physiological Phenomena by E. A. Hewitt; a section on Physiological Oxidations by J. B. Sumner; a chapter on Water, Electrolytes, and Acid-Base Balance by M. R. Kare; a part on Intermediary Metabolism by J. A. Dye; and a part on Endocrine Organs, Reproduction, and Growth by S. A. Asdell. Comstock Publishing Associates, a Division of Cornell University Press, Ithaca. $9.75. xii + 1020 pp. + 1 pl.; text ill. 1955.

This textbook of the physiology of domestic animals has, in the past, gained widespread acceptance in agricultural and veterinary colleges. The revised seventh edition should assure the text of continued acceptance. Besides bringing the text up to date, the editor has expanded it by the inclusion of additional chapters which offer some entirely new material. New chapters and material are offered in J. A. Dye's section on intermediary metabolism, which includes both biochemical and endocrinological data. A new chapter on water, electrolytes, and acid-base balance by M. R. Kare supplements the brief discussion which these topics receive in other parts of the book.

A physiology text on domestic animals contains many topics which remain untouched in human physiology texts. It is not surprising therefore to find that as compensation for this, the authors of *The Physiology of Domestic Animals* have abbreviated some of those sections which appear in greater detail in equivalent human physiology textbooks. To some, this may represent a shortcoming. To others with a bent toward the comparative, it will seem that some golden opportunities have been missed by not elaborating in greater detail upon the comparative aspects of the subject matter.

Yet, taken as a whole, this text will fill most of the needs of those for whom it was intended, i.e., animal husbandry and veterinary students embarked upon a basic course in physiology.

An appendix on "Lecture Demonstrations in Physiology" is another new feature of the seventh edition.

CLAUDE F. BAXTER

A Laboratory Manual of Physiology *for Veterinary Students.*

By Clyde F. Cairy. Burgess Publishing Company, Minneapolis. $4.00 (paper). x + 191 pp.; ill. 1955.

A Laboratory Guide for Elementary Physiology. *By Oscar E. Tauber, Delma E. Harding, and Robert E. Haupt. Burgess Publishing Company, Minneapolis.* $3.00 (paper). viii + 224 pp.; ill. 1955.

A Laboratory Manual for Elementary Physiology. *By Samuel R. Tipton and Helen L. Ward. Burgess Publishing Company, Minneapolis.* $2.25 (paper). vi + 75 pp.; ill. 1955.

Each of these is aimed at a different level of learning. Cairy's manual may be of interest to individuals other than veterinary students, for it contains some simple experiments which, while they may not be widely performed at present, could be adapted for inclusion in other laboratory courses in mammalian physiology.

The guide by Tauber *et al.* was prepared for use in a course offered to college freshmen majoring in Home Economics, who in some instances have had no high school work in biology or chemistry. The contents of this book are of necessity very elementary.

Some years ago this reviewer assisted in the courses for which Tipton and Ward wrote their manual. The students were usually on the college sophomore or junior levels and not biology majors, but with some background in science. In this manual some anatomy is included, but generally kept to a minimum. Noteworthy features are the presentation of enough chemistry to allow the student to grasp such concepts as p_H and buffer systems, and also the inclusion of some quantitative biology (efficiency, optimum load, etc.). The illustrations are simple and unusually clear.

A. Kurt Weiss

The Biochemistry and Physiology of Bone.

Edited by Geoffrey H. Bourne. Academic Press, New York. $20.00. xiv + 875 pp.; ill. 1956.

The current popularity of books by several outstanding authorities is easily understandable in that many advantages are accrued by such an arrangement. This volume on the biochemistry and physiology of bone is of such a variety, and performs an outstanding service. Reviews of numerous phases of investigation are presented in 24 chapters, each of which is adequately documented.

The first two chapters by J. J. Pritchard and G. H. Bell, respectively, deal with general topics of anatomy, histology, size, and strength of bone. While these chapters are not comprehensive in their coverage of the subject matter, they serve to introduce subsequent chapters on the ground substance (B. Sylven), the organic matrix (J. E. Eastoe), collagen fibers (C. Rouiller), and the ultrastructure and distribution of mineral salts (D. Carlstrom and A. Engstrom). The osteoblast and the osteoclast are discussed extensively by J. J. Pritchard and N. Hancox, respectively, and cover general cytology, function, origin, and fate. The relationship of phosphatase to bone formation and repair is considered by G. H. Bourne.

T. F. Dixon and H. R. Perkins evaluate the difficult subject of the chemistry of calcification. They begin by presenting the various concepts of bone salt compostion which have evolved from Berzelius in 1845 to current theories. The citric acid content, deposition, and metabolism in bone is also covered by these authors.

The use of Ca^{45}, P^{32}, C^{14}, and radioactive "bone-seeking elements" in the study of bone formation is presented in a chapter on autoradiographic studies by C. P. Leblond and R. C. Greulich. Osteogenesis in the human embryo and fetus by E. Gardner; skeletal development in tissue culture by H. B. Fell; the growth of bone by H. A. Sissons; and the repair and transplantation of bone by A. W. Ham and W. R. Harris follow, covering these specialized areas of knowledge.

Six chapters offer current information concerning the influence of vitamins and hormones on bone growth and development. These are: vitamin A by N. A. Barnicot and S. P. Datta; vitamin C by G. H. Bourne; vitamin D by L. J. Harris; steroid hormones by M. Silberberg and R. Silberberg; anterior pituitary by C. W. Asling and H. M. Evans; and parathyroid by F. C. McLean. The final two chapters involve the effects of radiation on bone by J. M. Vaughan and pathological calcification by G. M. Hass.

The scope and timeliness of this volume are certain to make it of considerable value to advanced students of physiology and biochemistry in the general area of calcified tissues.

R. Van Reen

Adrenal Cortex. *Transactions of the Fifth Conference November 4, 5, and 6, 1953, Princeton, N. J.*

Edited by Elaine P. Ralli. Josiah Macy, Jr. Foundation, New York. $3.75. 187 pp.; ill. 1954.

The series of conferences sponsored by the Josiah Macy, Jr. Foundation are "an attempt to stimulate research and to promote effective communication across the departmental walls which tend to isolate the professions and specialties from one another." For each series some 25 participants, specialists in the field under discussion and purposely drawn together from various scientific backgrounds, gather annually for a 2½ day conference. After 5 years the meetings are discontinued and another panel begins deliberations on a different topic.

The transactions of the 5th and, therefore, last conference on the "Adrenal Cortex" include the three papers presented at the meeting in November, 1953,

as well as the vivid discussions which either interrupted each presentation or followed it. In spite of the multiprofessional background of the participants, the present transactions deal almost exclusively with problems of a biochemical nature. H. L. Mason of the Mayo Clinic discusses the tedious procedure required to isolate a new crystalline mineralocorticoid which may be identical with the substances which Reichstein subsequently named aldosterone. While reading the discussion following this paper, my mind wandered back to the days when I was enrolled in the first course in Biochemistry and was required to read (in the original German) Buchner's simple, yet laborious, experiments with active yeast juice. How I marvelled at his persistence and stamina! Now I found myself admiring Mason who successfully prepared 2 mg. of the crystalline product from some 100 Kg. of adrenal glands.

Ralph I. Dorfman's lucid discussion of *in vivo* metabolism of the adrenocortical steroids in man is followed by a lengthy and involved discussion of urinary and blood assays of a large variety of steroids (or their degradation products. The clinically minded scientists will find a wealth of information here.

The last paper, presented by Frank G. Young of Cambridge University, posed the problem of whether ACTH is a single substance or a mixture of hormones. It is important to bear in mind that in this discussion ACTH is defined as "any pituitary substance acting on the adrenal gland in any respect." The perennial problem of impurities in the extracted fractions was again tackled, as even the purest ACTH preparations possess some melanophore-expanding activity which can be somewhat modified by chemical treatment. C. N. H. Long summarizes the conclusions reached quite aptly: "We certainly do not seem to have solved the question that was posed to us . . . I suppose the only thing we can say is that certain preparations of ACTH are most certainly a mixture of hormones. Whether there has yet been prepared a substance that presents the real tropic hormones of the adrenal cortex is undecided."

It would not be at all surprising if the Macy Foundation were to inaugurate a new series of discussions on the "Adrenal Cortex" in the near future.

A. KURT WEISS

THE HYPOPHYSEAL GROWTH HORMONE, NATURE AND ACTIONS. *International Symposium sponsored by the Henry Ford Hospital and Edsel B. Ford Institute for Medical Research, Detroit, Michigan and held at the Hospital October 27, 28, 29, 1954.*

Edited by Richmond W. Smith, Jr., Oliver H. Gaebler, and C. N. H. Long. The Blakiston Division, McGraw-Hill Book Company, New York, Toronto, and London. $12.00. xvi + 576 pp.; ill. 1955.

This volume will surely become a landmark in the literature dealing with the anterior pituitary growth hormone. It both summarizes the outstanding researches of a generation of investigators, and presents an exceptionally detailed and extensive account of the present state of affairs. It is thus a virtual encyclopedia written and, in the numerous and sometimes lengthy discussions, criticized by outstanding workers in the many different areas covered.

There are five sections: I) Bioassay, Preparation, and Physicochemical Properties of Growth Hormone, II) Effects of Growth Hormone on Certain Structures, III) Growth Hormone and Energy Sources, IV) Growth Hormone and Cellular Systems, and V) Influence of Growth Hormone on the Mammary Gland and on Human Metabolism. Each section is composed of five long papers except the section concerning energy sources which has ten. Many of the papers are handsomely illustrated with photographs and all are equipped with bibliographies. Most of the papers deal with basic research although several are clinical. The problems considered range all the way from the effects of growth hormone on mitochondria and the Kreb's cycle, to its action on the mammary gland of the cow. The symposium presents a vast mine of data, most of it extremely well organized. Yet there comes a feeling of frustration in reading this collection of papers. The true chemical structure of the hormone itself still eludes precise definition, although it is certainly a protein with a molecular weight of about 47,000. The whole subject of its mode of action still bristles with question marks. And as C. N. H. Long points out in his closing essay, the central problem of anterior pituitary physiology is as yet almost untouched. What regulates the secretion of the growth hormone or the changing sensitivity of the tissues to it at different ages?

Yet to expose the gaps in our knowledge and to suggest possible future lines of advance is surely one of the functions of a symposium, and is just as important as the presentation of the well ordered corpus of facts. This volume does both things well.

GAIRDNER B. MOMENT

RECHERCHES RÉCENTES SUR LA PHYSIOLOGIE ET LA BIOCHIMIE DE LA SÉCRÉTION LACTÉE. *Actualités Biochimiques No. 18.*

By S. J. Folley; translated by J. M. Gautier. Éditions Desoer, Liège; Masson & Cie., Paris. 1,850 fr. (paper). iv + 148 pp.; ill. 1954.

This review contains both experimental studies and theoretical discussions concerning recent and older literature in the field of physiology and biochemistry of milk secretion. It is divided into six chapters, the first of which is quite brief, and perhaps a somewhat

incomplete review of theories on normal postnatal mammary gland growth and the hormonal control of mammary gland development. For those interested in much of the English experimental data on the biochemistry and physiology of initiation and maintenance of lactation, and of the release of milk, the following three chapters are excellent. Unfortunately, in the discussion of many of the theories concerned, Folley only gives but fleeting notice to conflicting theories, and still less attention to data supporting them.

The final two chapters deal with fatty acid, lactose, and protein synthesis in the mammary gland. This section, dealing with a subject which has been primarily explored by English workers, was rather commendably done, giving an objective survey of the literature in this field.

This volume is particularly recommended to those whose interest is inclined more to the biochemistry than to the physiology of lactation.

CHARLES W. TURNER
HENRY DAMM

SHOCK AND CIRCULATORY HOMEOSTASIS. *Transactions of the Third Conference, September 14, 15 and 16, 1953, Princeton, N. J.*

Edited by Harold D. Green. The Josiah Macy, Jr. Foundation, New York. $3.50. 230 pp.; ill. 1954.

The substance of this book consists of three rather lengthy papers together with the comments of some 25 members and guests of the Josiah Macy, Jr. Foundation. These papers are (1) Experiences with shock in the Korean theater; (2) Reflex factors in the regulation of the circulation; and (3) Functional properties of blood vessels.

AN RH-HR SYLLABUS. *The Types and Their Applications. Modern Medical Monographs.*

By Alexander S. Wiener. Grune & Stratton, New York. xii + 82 pp.; ill. 1954.

A very brief treatment which runs the gamut of Rh blood groups and antibodies, their serology and genetics, the occurrence of erythroblastosis fetalis, the problems involved in blood transfusions, autosensitization, anthropologic aspects, and medicolegal applications—with no nonsense about CDe, etc., but good blackletter symbols, Roman and Gothic, with subscripts and superscripts, primes and double primes, for those with good memories. A remarkable amount of authoritative information has been assembled compactly here for those who want an introduction to the intricacies of the Rh blood group system.

BIOPHYSICS AND GENERAL PHYSIOLOGY

ADVANCES IN BIOLOGICAL AND MEDICAL PHYSICS. *Volume IV.*

Edited by John H. Lawrence and Cornelius A. Tobias; Editorial Board, H. J. Curtis, L. H. Gray, and Bo Thorell. Academic Press, New York. $8.80. x + 356 pp.; ill. 1956.

The present volume shows a departure from the trends in earlier volumes in that less emphasis has been placed on the radiation aspects of biological and medical physics, and a broader spectrum of interests is evident. Harker discusses the x-ray diffraction of crystalline proteins; Gamow and his colleagues, the problem of information transfer from nucleic acids to proteins; Mazia, his interesting studies on cell division; Wood, the lethal temperature effects on unicellular organisms; Freeman, infrared spectrometry; Huff and Judd, iron metabolism; Siri, the gross composition of the body; and Hardin Jones, aging processes, disease and life expectancy. The reviewer found the articles by Gamow and Mazia particularly pertinent and stimulating, but the others also appear to be informative, up-to-date, and ably handled.

C. P. SWANSON

THE PRESENT STATE OF PHYSICS. *A symposium presented on December 30, 1949 at the New York meeting of the AAAS.*

Arranged by Frederick S. Brackett. American Association for the Advancement of Science, Washington. $6.75; members, $5.75. vi + 265 pp.; ill. 1954.

The biologist will find this volume of interest because of the following articles: Structure of polymers (P. J. W. Debye); Chemical kinetics of some biological systems (R. Lumry and H. Eyring); Some physical and chemical properties of axons related to conduction of nerve impulses (F. Brink, Jr.); and Bioluminescence and the theory of rate control in living systems (F. H. Johnson). The remaining articles deal with elementary atomic particles and solid state physics, and contain little of immediate interest to the average biologist.

BIOPHYSIK DES FLIESSGLEICHGEWICHTS. *Einfuhrung in die Physik offener Systeme und ihre Anwendung in der Biologie.*

By Ludwig von Bertalanffy. Friedr. Vieweg & Sohn, Braunschweig. DM 4.80 (paper). 56 pp.; ill. 1953.

A very brief treatise which will be of interest to those concerned with the kinetics and thermodynamics of open biological systems, dynamic equilibria, homeostasis, and kindred topics.

ANNUAL REVIEW OF NUCLEAR SCIENCE. *Volume 4. Edited by James G. Beckerley; associate editors, Martin D. Kamen and Leonard I. Schiff. Annual Reviews, Stanford.* $7.00 (U.S.A.); $7.50 (foreign). x + 483 pp.; ill. 1954.

ANNUAL REVIEW OF NUCLEAR SCIENCE. *Volume 5. Edited by James G. Beckerley; associate editors, Martin D. Kamen, and Leonard I. Schiff. Annual Reviews, Stanford.* $7.00. x + 448 pp.; ill. 1955.

The general organization of the Annual Review of Nuclear Science will be familiar to biologists who have read the Annual Reviews of Biochemistry, Microbiology, Physiology, or Plant Physiology. The subject matter is different, of course and the chapters incline more toward current reviews of the literature, and less toward general reviews, than they do in the biological volumes. About half the chapters, in nuclear physics and engineering, are outside the interests of most biologists, even of radiobiologists; the remaining half is about equally split between subjects directly and indirectly related to radiobiological problems.

Among the seventeen chapters in the 1954 volume (which survey the literature up to Jan.-Apr. 1954) are Biochemical Effects of Radiation, by K. P. DuBois and D. F. Petersen, and Vertebrate Radiobiology (Lethal Actions and Associated Effects), by J. F. Thomson. The first considers primarily the action of radiation on enzyme systems, and the authors conclude that it is not yet possible to ascribe radiation damage to interference with specific enzyme systems. G. G. Manov's chapter on Standardization of Radioactive Sources will be pertinent to scientists employing radioisotopes; recent and best values for half lives, energies, decay schemes, and availability of standards, are reviewed.

The 1955 volume, number 5 (survey of literature up to Dec. 1954–Apr. 1955) contains more for the biologist. Mortimer and Beam's chapter on Cellular Radiobiology is a well organized and thorough survey of the literature from 1952–1954; it takes up after the period surveyed by Sparrow and Forro in their review on the same subject in Volume 3. Edelmann's chapter on Vertebrate Radiobiology: Physiology is brief and not up to the standard of its predecessors in the group. A chapter on Removal of Radioelements from the Mammalian Body by J. Schubert is timely, especially since there have been no previous reviews of the subject. The Fundamentals of Radioautography by Norris and Woodruff, and Radiation Chemistry by Dainton bear on biological problems. There is a fascinating and very well written section on bubble chambers in the chapter by W. B. Fretter on Nuclear Particle Detection (Cloud Chambers and Bubble Chambers). The 1955 volume has a cumulative index to chapter titles for volumes 1–5. The reviewer himself was surprised, and suspects that others may be also, at the amount of material in radiobiology and related subjects that has been published in the five volumes.

ALAN D. CONGER

SMALL-ANGLE SCATTERING OF X-RAYS. *By André Guinier and Gérard Fournet; translation by Christopher B. Walker; followed by a bibliography by Kenneth L. Yudowitch. John Wiley & Sons, New York; Chapman & Hall, London.* $7.50. xii + 268 pp.; ill. 1955.

This monograph, written by two of the foremost workers in the field, contains an extensive treatment of the phenomenon of small-angle scattering of x-rays both from the theoretical and experimental points of view. They begin with a description of the phenomenon and an investigation of its physical significance. There then follows a lengthy chapter on the theoretical aspects of small-angle scattering which includes, according to the authors, the most important problems solved to date together with an indication of the limitations yet to be overcome. The third chapter presents a discussion of the various experimental methods that have been employed, with emphasis on the general principles that should be followed in designing a small-angle scattering system. The problem of the interpretation of experimental results is discussed in the fourth chapter and several instructive examples are given. A comparison of the results of small-angle x-ray scattering studies with other methods for determining particle size is given in Chapter Five and the last chapter is devoted to the applications of the technique to problems in chemistry, biology and metallurgy. Worthy of note is the fact that the book is written both for the expert and the novice, the first chapters being for the former and the last chapter for the latter. From reading the last chapter alone the chemist, biologist or metallurgist should be able to decide on the advisability of attacking a given problem by the small-angle scattering technique. The bibliography is extensive, containing 569 titles in all. There is little doubt that this book will serve as a standard reference on the subject of small-angle scattering of x-rays for some time to come.

FRANCIS D. CARLSON

COMPTES RENDUS DU PREMIER CONGRÈS INTERNATIONAL DE MICROSCOPIE ELECTRONIQUE, *Paris, September 14–22, 1950. Mémoire Hors Série No. 1. De la Revue d'Optique Théorique et Instrumentale, Paris.* (paper). viii + 768 pp.; ill. 1953.

Some 96 articles on electron microscopy and related topics, delivered at the First International Congress of Electron Microscopy in Paris, September 14–22, 1950, make up this volume. They deal with techniques, lenses, quality of images, diffraction studies and the

usefulness and results of the various approaches to problems in metallurgy, chemistry and biology. They represent, therefore, a good cross-section of the research going on in this field in the Americas, Europe and Asia. The volume suffers in one respect: the poor quality of the paper has impaired the clarity and sharpness of many of the photographs.

OPTICAL INSTRUMENTATION.

By Members of the Staff of the Optics Section, Metallurgical Laboratory, University of Chicago; edited by George S. Monk and W. H. McCorkle. McGraw-Hill Book Company, New York, Toronto, and Canada. $3.75. xxvi + 262 pp.; ill. 1954.

This volume is a report of work carried out under the Manhattan Project and, later, by the Atomic Energy Commission. It is concerned with the instruments and methods used in handling radioactive materials from which the observer must be protected by heavy shields. As such, it is largely an account of remote control manipulations. The book is only of cursory interest to the biologist.

BIOCHEMISTRY

NOTIONS ÉLÉMENTAIRES DE CHIMIE GÉNÉRALE. *A la Lumière des Théories Modernes. A l'Usage des Étudiants, des Chimistes et des Biologistes.*

By Paul Pascal. Masson & Cie., Paris. 3,600 fr. (paper). xxxi + 550 pp.; ill. 1953.

What is here termed "chimie générale" would commonly be included in this country in textbooks of physical chemistry, but the scope of the present work is somewhat broader and more general. The treatment is clear, up to date in most respects, and very stimulating to read. It begins with a historical sketch of the evolution of ideas regarding the nature of matter, continues with a consideration of the dispersion and discontinuity of matter, the structure of the atom and the nature of isotopes, spontaneous and artificial transmutations of nuclear structure, molecular and ionic structures, macrostructures, and the nature of bonds and their rupture. There follows a long section on the kinetics of chemical reactions, including catalysis. This section is succeeded by another on chemical equilibria, thermodynamics, and the different states of matter. Liquid solutions, surface phenomena, and dispersed systems, including microcrystalline dispersions and macromolecular or macroionic dispersions, come in for special attention. A section of plates at the beginning of the volume figures, among others, such systems as tobacco mosaic virus crystals, anthracene crystals, and phthalocyanin molecules, as seen with the electron or electron-field microscopes. The volume is well indexed, having both Subject and Author Indexes.

MONOMOLECULAR LAYERS. *A symposium presented on December 27, 1951, at the Philadelphia meeting of the American Association for the Advancement of Science.*

Edited by Harry Sobotka. American Association for the Advancement of Science, Washington. $4.25; members $3.75. viii + 207 pp.; ill. 1954.

Seven of the 9 papers included in this volume deal with the physical and chemical properties of monolayers, one is concerned with the determination of molecular weights through the use of monolayers, and one with modern film techniques and their application to biochemical reactions. The book will be of limited value to most biologists, but is of importance to those who deal with the behavior of surfaces and membranes.

ELECTROMETRIC pH DETERMINATIONS, *Theory and Practice.*

By Roger G. Bates. John Wiley & Sons, New York; Chapman & Hall, London. $7.50. xiv + 331 pp.; ill. 1954.

Approximately half of this book is devoted to the more pertinent aspects of thermodynamics, of the theory of electric cells without and with transference (and the problems of so-called liquid junction potentials associated with the latter type of cells) of non aqueous solutions, and, more particularly, to a summary of the intricate problems involved in standardizing scales. Approximately half is devoted to apparatus and technique, and to such theories as apply more specifically to cells containing hydrogen, glass, and other electrodes. Comparatively little is written on the theory of acid-base equilibria and its innumerable applications.

It is now well known that no means have been devised to determine precisely an electrochemical potential, or activity, of ions of a single kind. Here originate different points of view. One extreme is that pH, defined as the logarithm of the reciprocal of hydrogen-ion activity, has no physical meaning whatever. Another view is that a hydrogen electrode at constant temperature, and under constant partial pressure of hydrogen, responds to the electrochemical potential, or activity, of protons, or solvated protons (e.g., H_3O^+), and that either the electrochemical potentials, or the activities, will inevitably be used in basic formulations of equilibrium states. But there also remain the limitations of information revealed by those who have examined the physical operations used in this field. The practical outcome has been the adoption of an operational definition of pH and the arbitrary assignment of a pH number to each of several standard solutions at each of several temperatures.

These numbers may never be accepted by the devotee of rigorous thermodynamics. The student of operations should still be too busy to care how the numbers are used. Those who use them in accordance with the aforesaid views of the hydrogen electrode and basic formulations of equilibrium states will find the numbers acceptable if, relative to one another, they provide reasonably close approximations to ideal relations or serve to establish uniformity in reported data where correlations between certain phenomena and *p*H numbers are more important than the absolute values of these numbers.

The reviewer congratulates Bates on his clear exposition of this battle in the wilderness, and on having participated effectively with his associates in the National Bureau of Standards in establishing tentatively acceptable standards which, as such, have been widely accepted. Some readers who are more interested in practice than in theory may complain that, of this rather short treatise, a disproportionate space has been devoted to this subject which has been reviewed elsewhere by Bates. But the reader who is aware of Bates' contributions will make the appropriate concession. Some experts may say that, in the papers on this subject from the Bureau, undue weight has been given to calculations with the extended equation of Debye and Hückel. But then what is to be used?

Incidentally the reviewer hopes that the symbols *pa*H, *pd*H, *ps*H, *pw*H, etc., which are used to distinguish different operational bases of different scales, will not come into general use. He is of the opinion that use of a little more printing ink would have been preferable.

Some readers could have hoped that the author, who has a keen appreciation of the importance of operational bases, should have chosen the convention of signs that can be based on the operations of potentiometry. Instead, he chose the opposite convention which is based on conventional ways of *writing* descriptions of cells and cell reactions. One of several results is that the "potentials" of hydrogen and quinhydrone electrodes, relative to the standard, have signs opposite to those of the respective terminals. This is known to have caused confusion in practical potentiometry. Lacking reference to a few simple line charts bearing on this matter, a reader may have difficulty in keeping orientations clear. Perhaps no subject is more overburdened by conventions, expressed, implied, and hidden, than is electrochemistry. A student may well ask: What in very precise terms is the relation between the algebraic uses of the signs + and − , and the use of these signs to distinguish two kinds of electricity? What in very precise terms is the justification for giving the minus sign to a physically measured electromotive force? Are the answers to these and similar questions so well known to everyone that they can be ignored in textbooks?

It can be said justly that the foregoing remarks have no place in this review. They are included as illustrating the reviewer's feeling that at several other points in the book the author, a distinguished investigator, shows that he is somewhat isolated from the needs of students.

Some of the discussions of the effects of temperature changes would have been more illuminating had the author included *there* G. N. Lewis' *reason* for adding to the older definition of the standard hydrogen half-cell the specification that the potential difference between electrode and solution shall be regarded as zero *at any temperature*.

In considering apparatus and techniques, on which there is an enormous literature, the author must have debated whether to be comprehensive or selective. In the opinion of the reviewer, Bates was wise in being selective and he has selected wisely. Accordingly, there can be no complaint if here and there an important matter seems to have been treated too briefly or some fine point in a technique is neglected. In a few instances, either brevity, or failure to assemble in one place, the remarks that bear upon a matter may leave the reader confused. For example, a reader of some statements might gain the impression that it suffices for the standardization of a cell with a glass membrane to use only one standard solution. Of course, this will not do for refined measurements even in the more favorable range of *p*H as is clearly implied, or stated explicitly, elsewhere.

The statement that the quinhydrone electrode "behaves as a true hydrogen electrode" misses the fundamentally important theorem of a *coupling* of two processes that have been *formally* distinguished in chemistry.

A few of the diagrams lack details that would have clarified the operation of the apparatus they depict. A novice would like to know the signs of the cell terminals of the Weston cell depicted on page 257. Fortunately, there are comparatively few of those nice pictures of the *exteriors* of beautiful apparatus with which some authors adorn, and adorn only, their texts. On the whole the diagrams are illuminating.

The reviewer confesses that he has not checked all equations and numbers. No mistakes were found where checks were made. On the whole the expositions are lucid.

This is an invaluable book. It will have to be used, and doubtless will be used, with satisfaction by all persons who desire to know precisely what they are doing when they use any one of the numerous devices now readily available for the electrometric measurement of *p*H. These will include a large proportion of chemists, almost all biochemists and very many in other fields. Unfortunately the reviewer's experience has been that many of these have ignored what Bates emphasizes, namely that the hydrogen cell remains the basic instrument and other devices are secondary.

W. Mansfield Clark

A Short Textbook of Colloid Chemistry.

By B. Jirgensons and M. E. Straumanis. John Wiley & Sons, New York; Pergamon Press, London. $8.00. xvi + 420 pp.; ill. 1954.

Although an apparent first edition, the present book is actually a revised version of an earlier text in German, published in 1949. It is written for students interested in the natural sciences, and in particular for those concerned with colloid chemistry as it applies to medicine, pharmacy, and industry.

The book is divided into two parts, the first dealing with basic facts and fundamental principles without too much theoretical implication, and the second treating of light-scattering, electrophoresis, ultracentrifugation, viscosity, electron microscopy, x-ray analysis, etc., as these apply to colloids and the problems dealing with colloidal systems. The properties of colloids as functions of the sizes and shapes of the constituent molecules are also considered. The cellular physiologist, in particular, will find this volume informative and readable.

The Chemistry of Living Cells.

By Helen R. Downes. Harper & Brothers, New York. $7.50. x + 549 pp.; ill. 1955.

This new text in biochemistry is designed for use in an introductory college course for seniors. The 15 chapters are classified under three parts. Part I (3 chapters), entitled Some Preliminary Considerations, deals with history, some general properties of aqueous solutions, and the structure of living forms. Part II (4 chapters) treats the chemistry of carbohydrates, nitrogen compounds, lipids and enzymes. The eight chapters of Part III are concerned with intermediary metabolism. In general, the level of the book is appropriate for the senior student who has an adequate background in chemistry, and the viewpoint, as a whole, is up-to-date. The chapters on intermediary metabolism deal with matters of current interest, and reflect the advances of the past decade very well, although it is unusual to find the pathways of carbohydrate and lipid metabolism described before biological oxidations. Some criticism can be made of the space allotted to various topics, although this is, to some extent, a matter of taste. However, 69 pages are devoted to the chemistry of carbohydrates whereas 60 pages are given for amino acids, proteins, nucleoproteins and a number of non-protein nitrogenous compounds. The "cyclol" hypothesis of protein structure is described for more than a page, but the amino acid sequence of insulin is not given and is dismissed in a few sentences. Despite these and other criticisms, the book is a useful contribution toward the teaching of undergraduate students.

Emil L. Smith

The Harvey Lectures. Series L. *Delivered under the Auspices of The Harvey Society of New York 1954–1955, under the Patronage of the New York Academy of Medicine.*

By Vincent DuVigneaud, Richard J. Bing, J. L. Oncley, André Lwoff, Ephraim Shorr, George O. Gey, Bernard D. Davis, David Shemin, and Eugene L. Opie. Academic Press, New York. $8.00. x + 421 pp. + 1 pl.; text ill. 1956.

With the publication of this volume, the Harvey Lectures celebrate their 50th anniversary. During these years they have served to present more than 400 lectures. In the words of Dr. Haven Emerson: "... every major factor in what we think of as the phenomenal progress in prevention of sickness and care of the sick in the 20th century has been announced, defined, confirmed or expanded ... in a Harvey Lecture." He further states: "The quality of timeliness, the solidity ... of these lectures ... have been of such enduring significance that one cannot with honesty discriminate among them by pointing out a special distinction of those which signalized great changes in medical thought and practice."

This latter pronouncement would serve well as an epitaph for the present volume of the Harvey Lectures, which covers the period from September 1954 to May 1955. During this interval, Dr. Vincent DuVigneaud presented an account of his group's research which led to the chemical synthesis of a hormone. The chapter shows that Dr. DuVigneaud has the enviable ability to summarize in a few simple sentences the essence of months of painstaking research.

The metabolism of the heart was discussed from a biophysical and physiological point of view by Dr. Richard J. Bing, and in a lecture on the lipoproteins of human plasma, Dr. J. L. Oncley took a predominantly biochemical look at this class of blood constituents, whose clinical aspects have been the topic of so much controversy and research. In December of 1954, Dr. André Lwoff described to the society some of the milestones in the study of bacteriophages. In his chapter entitled "Metabolic and viral disease of bacteria" he foreshadowed some of the recent developments in this field.

Classically, enzymes and hormones have been isolated *after* their physiological effects became known. Ferritin, the iron-rich protein, is an exception to this rule. First crystallized in 1937, its hormonal, enzymatic, regulatory and storage functions are only gradually becoming apparent. The late Dr. Ephraim Shorr reviewed the discovery of some of these functions in the first Harvey Lecture of 1955.

A beautifully illustrated chapter on some aspects of the constitution and behavior of normal and malignant cells maintained in continuous culture represents the contribution of Dr. George O. Gey. Microscopic morphological differentiation, resistance to virus infection and interconversion were discussed in this lecture.

Dr. Bernard D. Davis' talk on the biochemical exploration with bacterial mutants concerned itself chiefly with aromatic biosynthesis as a topical illustration of the extent to which the use of auxotrophic mutants of microorganisms has helped us clarify intermediate metabolic pathways. Another technique of studying intermediate metabolism was presented in the lecture of Dr. David Shemin. His description of studies using C^{14}-labeled metabolites to elucidate porphorin biosynthesis places another milestone of scientific research into the literature of the Harvey Lectures.

Besides a chapter by Dr. Haven Emerson of the Harvey Society itself, a talk by Dr. Eugene I. Opie on the osmotic activity in relation to the movement of water under normal and pathological conditions concludes the volume.

CLAUDE F. BAXTER

ANNUAL REVIEW OF BIOCHEMISTRY. *Volume 24.*

Edited by J. Murray Luck; associate editors, Hubert S. Loring and Gordon MacKinney. Annual Reviews, Stanford. $7.00. xvi + 805 pp. + 1 pl.; text ill. 1955.

This twenty-fourth volume of an illustrious series testifies by its increased content to the burgeoning growth of the field of biochemistry. The general topics are the same as those covered in recent years, beginning with an excellent chapter on Biological Oxidations by Beinert and Green. Of particular interest are chapters on the Chemistry of the Phosphatides by Baer, the Chemistry of Proteins, Peptides, and Amino Acids by Ogston, the Carotenoids by Goodwin, the Clinical Applications of Biochemistry by Bodansky, and a masterful review of Lipide Metabolism by Lynen.

As is always the case in a compilation of reviews, there is a galaxy of styles which lends some interest to the volume as a series of variations in a heavy diet of reading. The unusual design of the review of protein chemistry by Ogston deserves particular comment since it represents what seems to this reviewer to be a good solution to the increasingly vexing problem of presenting all of the work in the field in a concise presentation. Dr. Ogston has appended 353 references, grouped under seventeen headings, and has described each article in a brief phrase. As a result, he has produced the shortest text (eight pages) of any other review. This text is very interestingly written with much more airing of the author's opinions than is to be found in the rest of the volume. As time goes on, it might be wise to adopt this form of review.

This latest volume of the Annual Review of Biochemistry will furnish excellent secondary reference material and should be profitable reading for all those interested in the general field of biochemistry.

SAMUEL P. BESSMAN

6-MERCAPTOPURINE. *Ann. N. Y. Acad. Sci., Vol. 60, Art. 2.*

Edited by Roy Waldo Miner; consulting editor, C. P. Rhoads; conference co-chairmen, George H. Hitchings and C. P. Rhoads; 84 other contributors. The New York Academy of Sciences, New York. $4.50 (paper). Pp. 183–508; ill. 1954.

On April 30–May 1, 1954, a conference was sponsored by the New York Academy of Sciences on the effects of the purine analogue 6-mercaptopurine, and this volume of 41 papers has resulted. It is far too extensive to permit a detailed discussion, or even a listing, of its contents. Suffice it to say that the volume will remain an authoritative reference on the subject for a considerable time to come, and that it deals with such topics as the biosynthesis of nucleic acids, the biochemistry of purine analogues, microbiological effects of 6-mercaptopurine, embryonic effects, effects on regenerating tissues, effects on tissue cultures, experimental tumors, leukemias in mice and men, and clinical results obtained with 6-mercaptopurine in the treatment of leukemia and other neoplastic diseases.

A sorry deficiency of so important and large a volume is its lack of an index.

ISOTOPIC TRACERS. *A Theoretical and Practical Manual for Biological Students and Research Workers.*

By G. E. Francis, W. Mulligan, and A. Wormall; foreword by G. Hevesy. University of London, The Athlone Press, London. $7.00. xvi + 306 pp.; ill. 1954.

This definitive manual of the theory and practice of the use of isotopic tracers in physiological and biochemical work comes from members of the staff of the Biochemical Laboratory of St. Bartholomew's Hospital Medical College in London, an institution which was among the first to pioneer in the use of such methods. The Foreword by Hevesy hails the work as a book by highly competent men of great experience, and a book certain to be enthusiastically received by students and teachers alike. The theoretical part of the volume covers in 11 chapters the full scope of necessary background, the nature of the preparation and synthesis of both radioactive and stable isotopes and of labeled compounds, the properties of isotopes, methods of measurement for both stable and radioactive isotopes, autoradiography, hazards and precautions in use, and illustrative examples. The practical course gives methods centered on the use of N^{15}, P^{32}, and I^{131}. There are several appendices of special methods and tabular data; and there is a good index.

RADIOISOTOPE CONFERENCE, 1954. *Proceedings of the Second Conference Oxford, July 19–23. Sponsored by*

the Atomic Energy Research Establishment, Harwell. Volume I: Medical and Physiological Applications. Volume II: Physical Sciences and Industrial Applications.

Edited by J. E. Johnston, assisted by R. A. Faires and R. J. Millett. Academic Press, New York; Butterworths Scientific Publications, London. Vol. I, $10.80; Vol. II, $7.50; 2 volume set $16.00. I; xii + 418 pp.; ill. II; x + 223 pp.; ill. 1954.

Assembled here are no less than 70 papers with their discussions, about two-thirds of them devoted to medical and physiological applications in Volume I, the other third to physical sciences and industrial applications in Volume II. What were sessions at the conference now amount to chapters in the two volumes, which consider the following subjects: therapy, diagnosis, animal physiology and pathology, biochemistry (three sessions), plant nutrition and allied subjects, in Volume I; chemistry, chemistry and metallurgy, physics and industrial applications, industrial applications, in Volume II. Most of the papers are reports on current research and results, rather than reviews, contributed by a cosmopolitan group of scientists from all over the world; all papers are in English, however.

The reviewer did not find any startling new results or information in the papers in his own special field of interest, nor did he consider any of them major contributions to the field, and is inclined to believe that other readers will have the same opinions about the papers in their own particular fields. Probably the most valuable part to a reader will be the information and ideas embodied in the papers in subjects other than his own, ideas or information that normally might not be encountered among the workers in his own field, but which can be applied directly to his own work. Proper evaluation and judgment of a paper is aided considerably by the discussions, often rather pointed and sometimes amusing, at the end of each paper.

The contents of these two volumes, although never stated as such, are an impressive testimony to the tremendous value of radioisotopes in scientific research, and are material evidence that the enthusiastic predictions of a few years ago already have been realized.

ALAN D. CONGER

CHEMISTRY OF LICHEN SUBSTANCES.

By Yasuhiko Asahina and Shoji Shibata. Japan Society for the Promotion of Science, Ueno, Tokyo. $2.50. vi + 240 pp.; ill. 1954.

Chemical substances isolated from lichens are of interest from three points of view: 1) their antibiotic possibilities; 2) their relationship to the peculiar symbiotic existence of a fungus and an alga; and 3) their usefulness in determining possible systematic connections within the whole group of lichens. The study of such substances has been largely done by Japanese workers, and at present the only information available is the chemistry of certain isolated derivatives. This volume is essentially a report of the progress which has been made in this field of rather limited biological interest.

ZEIN. *Corn Protein, An Annotated Bibliography 1891–1953. Mellon Inst. Bibl. Ser. Bull. No. 7.*

By Dorothy M. Rathmann. Mellon Institute of Industrial Research, Pittsburgh. Free upon request (paper). vi + 118 pp. 1954.

Zein is an alcohol-soluble protein, derived from the endosperm of maize, which has found wide industrial application as an ingredient in coatings, films, fibers and adhesives. Some 942 citations, including patents, are listed and grouped according to subject matter. Brief notes accompany each article of importance.

WOOL. *Its Chemistry and Physics.*

By Peter Alexander and Robert F. Hudson. Reinhold Publishing Corporation, New York; Chapman & Hall, London. $10.00. x + 404 pp. + 14 pl.; text ill. 1954.

This volume is addressed principally to textile workers, but the biologist and chemist concerned with proteins will find certain chapters valuable if only because many of the principles of protein chemistry were first worked out on wool fibers.

INDUSTRIAL FERMENTATIONS. *Volume II.*

Edited by Leland A. Underkofler and Richard J. Hickey. Chemical Publishing Company, New York. $12.00. xii + 578 pp.; ill. 1954.

This excellent compilation contains 14 chapters by various specialists on ketogenic fermentations, the 2,3-butanediol fermentation, fungal amylolytic enzymes, other fungal and microbial enzymes, riboflavin production, production of other enzymes, penicillin, streptomycin, and miscellaneous antibiotics. There are also chapters on miscellaneous fermentations, lactic acid fermentation of cucumbers, sauerkraut, and olives, culture maintenance, cultural variation and genetics, and fermentation treatment of wastes. Each chapter is followed by a large number of references, arranged by authors in alphabetical order. The subject index is excellent.

For anyone wishing accurate and comprehensive accounts of the topics covered in the 14 chapters, the book can be very highly recommended. It should be of great value for reference. Unfortunately, the price is perhaps a little too high to make the book generally useful as a teaching text.

WALTER C. TOBIE

ANDROGENS. *Biochemistry, Physiology, and Clinical Significance.*

By Ralph I. Dorfman and Reginald A. Shipley. John Wiley & Sons, New York; Chapman & Hall, London. $12.50. xviii + 590 pp.; ill. 1956.

The androgenic hormones, less accurately known as the male sex hormones, are now known to regulate some aspects of systemic protein anabolism in both sexes, in addition to their role in the physiology of reproduction. The far reaching significance of androgenic function, and the considerable research activity in this field, fully justify the present monograph, which is the first to be devoted to the subject of the androgens. About half of the space is devoted to the biochemistry and animal physiology of androgens, and half to clinical aspects. The clinical section is well written, being thoughtful and careful in its evaluation of evidence, and appeared to this reviewer to be more satisfactory than the physiological section. This may in part be due to the nature of the material under consideration: clinicians being more interested than physiologists in the long range fate of their subjects, often make the careful long term observations that are needed in endocrinology, and since they have some interest in the organism as a whole, they are in a favorable position to receive lessons in humility.

The biochemistry of the androgens is discussed systematically, according to the source from which the compounds have been isolated, general principles of urinary extract preparation, and assay methods. There is an excellent summary of androgen metabolism; relative activities and qualitative differences between androgens are discussed briefly, as well as the complicated problem of the factors influencing androgenic activity. In an appendix there is a listing of 225 structural formulae, and details of extract preparation and chemical and biological assay methods.

The monograph can be expected to be extremely useful in that it brings together the findings of a great deal of research from the fields of biochemistry, physiology and the clinics. However, the chapters dealing with the biology and physiology of androgens suffer from being too cursory, too condensed and not well integrated. The discussion of the role of androgens in embryonic differentiation does not do justice to the broader implications of the subject, since the role of androgens in sex differentiation cannot be well evaluated without more consideration of the evidence regarding estrogen effects, particularly the work of Burns who has contributed an important degree of order to a confused field. In the chapter on the actions of androgens on sex structures of animals, 208 articles are referred to in 30 pages. The reviewer's contributions to this field came up pretty badly mangled, inasmuch as a 1939 study suggestive of the secretion of androgen by the mouse adrenal was quoted, rather than a direct 1946 test, in which no appreciable androgen production by the mouse adrenal could be detected by seminal vesicle reactivity. Furthermore, the curious distinction between rats and mice in this respect was overlooked, rats being credited with having an adrenal X zone, whereas actually in the rat, which does not have a differentiated X zone, the adrenal does produce detectable amounts of material which supports the prostate, but only during a part of the age span during which the X zone is present in the intact mouse. In view of the inevitable limitations of literature surveys, it would seem distinctly preferable to include titles in the bibliographies of monographs of this nature, since the title may be expected to have sufficient bearing on what the author was trying to say to make it worth its space, if the article is worth comment. Other lapses which the reviewer happened to notice include the statement on page 397 that the adrenal of the human male is larger than that of the female. No measurements were given. This statement is contrary to the careful measurements of Swinyard. In Chapter 11 *phylum* is repeatedly used as is synonymous with *class*. In spite of these defects, however, I shall keep the volume close at hand, under affectionately skeptical scrutiny. The monograph should be a valuable working companion to anyone interested in steroids.

EVELYN HOWARD

MÉCANISMES BIOCHIMIQUES DE L'ACTIVITÉ DES ANTIBIOTIQUES (*Pénicilline, Streptomycine, "Tyrothricine"*).

By Maurice-Marie Janot and Kean Keufer. Masson & Cie., Paris. 670 fr. (paper). iv + 74 + ii pp.; ill. 1953.

A brief but useful account of the cellular and biochemical action of three famous antibiotics, the first two of fungal origin, the third of bacterial origin. Other antibiotics, including chloramphenicol, aureomycin, terramycin, and others less familiar, are compared with these as to chemical structure. There is an extensive bibliography of 433 cited works, but no index at all.

RESERPINE (SERPASIL) AND OTHER ALKALOIDS OF *Rauwolfia Serpentina;* CHEMISTRY, PHARMACOLOGY, AND CLINICAL APPLICATIONS. *Ann. N. Y. Acad. Sci., Vol. 59, Art. 1.*

Edited by Roy Waldo Miner; consulting editor, Frederick F. Yonkman; 35 contributors. New York Academy of Sciences, New York. $3.00 (paper). Pp. 1–140 + 1 pl.; text ill. 1954.

The great current interest in reserpine and other tranquillizing drugs makes this symposium of particular interest. Reserpine is only one of at least 14 alkaloids known to occur in *Rauwolfia*, and the chemical and pharmacological study of the others may in time develop many other valuable uses. The contents of the

symposium were as follows: Chemistry of *Rauwolfia* Alkaloids, including Reserpine (E. Schlittler and 8 coauthors); Pharmacology of *Rauwolfia* Alkaloids, including Reserpine (A. J. Plummer and 4 coauthors); Endocrine Aspects of the Pharmacology of Reserpine (R. Gaunt and 4 coauthors); Clinical Usage of *Rauwolfia* Alkaloids including Reserpine (Serpasil) (R. W. Wilkins); Clinical and Experimental Effects of Reserpine in Patients with Essential Hypertension (E. D. Freis and R. Ari); Intravenous Reserpine in Patients with Essential Hypertension (J. H. Hafkenschiel and A. M. Sellers); Human Pharmacology of Reserpine (T. Winsor); Cardiovascular and Renal Hemodynamic Response to Reserpine (Serpasil), and Clinical Results of Using this Agent for the Treatment of Hypertension (J. H. Moyer); Clinical Use of Reserpine (Serpasil) in Geriatrics (R. Harris); Use of *Rauwolfia serpentina* Benth. in Neuropsychiatric Conditions (N. S. Kline); Use of Reserpine (Serpasil) in Certain Gynecologic Disorders (R. B. Greenblatt); and Clinical Experience with Reserpine (Serpasil): A Controlled Study (Harriet P. Dustan and 3 coauthors).

THE CHEMICAL PATHOLOGY OF ANIMAL PIGMENTS. *Biochem. Soc. Symp., No. 12. A Symposium Held at the London School of Hygiene and Tropical Medicine, Feb. 20, 1954.*

Organized and edited by R. T. Williams. Cambridge University Press, New York. $2.75 (paper). iv + 84 pp.; ill. 1954.

MICROBIOLOGY

ENZYME, ANTIGEN AND VIRUS. *A Study of Macromolecular Pattern in Action.*

By F. MacFarlane Burnet. Cambridge University Press, London; [Cambridge University Press, New York]. $5.00. viii + 193 pp.; ill. 1956.

This brilliantly written book presents the views of an outstanding biologist on fundamental problems of the life sciences. It is much more than a revised edition of *Production of Antibodies* published by the same author with F. Fenner in 1949. Burnet, in his new book, tries to develop a general theory of protein biosynthesis, and to correlate adaptive enzyme formation with antibody production, malignant growth and virus multiplication. The basis for Burnet's ideas is the principle of mutual complementariness of template and product. In contrast to the reviewer, Pauling and other authors, Burnet believes that the antigen cannot persist in the foreign organism over long periods of time, and that it is replaced by "genocopies" which act as templates for the formation of antibodies. The phenomenon of prenatally acquired tolerance is attributed by Burnet to the presence of "recognition units" which combine only with homologous proteins and, thereby, prevent the formation of antibodies against these. The templates are represented by the symbol RNA+ where the + indicates the combination of RNA with a polypeptide or another substance. These short remarks may give an idea of the intriguing problems treated in this book. Some of the weak and debatable statements of the previous edition have been abandoned and replaced by more convincing views. The reviewer does not share the author's pessimistic belief that "orthodox chemical principles are inadequate to deal with questions of pattern transfer and replication." To the chemist and, probably, to most biologists symbols such as "recognition unit," "genocopy," or "self-marker" have little meaning unless they can be expressed in terms of molecular structure and conformation. The last chapter of the book is devoted to problems of general importance such as the purpose of basic research and criteria for its quality. With resignation and some sense of humor the author states that research, in order to be "acceptable" in academic circles, has to lead to results which are "new, but not so novel that they cannot be readily related to the results of previous work" and that "really great generalizations of biology are outside the normal process of investigation." This may be true; nevertheless the reviewer is convinced that most readers will be grateful to Sir F. Macfarlane Burnet for the generalizations he made in this interesting book.

F. HAUROWITZ

ADVANCES IN VIRUS RESEARCH. *Volume II.*

Edited by Kenneth M. Smith and Max A. Lauffer. Academic Press, New York. $7.00 x + 313 pp.; ill. 1954.

ADVANCES IN VIRUS RESEARCH. *Volume III.*

Edited by Kenneth M. Smith and Max A. Lauffer. Academic Press, New York. $8.00. x + 339 pp.; ill. 1955.

This addition to the "Advances" on various topics is gradually outgrowing its birth pains—summary articles on arbitrarily delimited aspects of viruses—and maturing into collections of expressive essays on topics that will interest authors and readers equally. Insofar as the technical journals and reviews fail to fill this need, the "Advances" and similar series perform an important function, albeit their typically higher costs permit a more limited distribution. The readers of this journal will not be unduly concerned at the broad conceptions of relevance entertained by the editors.

Volume II includes "Inheritance of resistance to viral diseases in plants" by F. O. Holmes; "Inhibitors and plant viruses" by F. C. Bawden; "Incomplete forms of influenza virus" by P. von Magnus; "Characteristics of viral development in isolated tissues" by

W. W. Ackermann and T. Francis; "The action of ionizing radiations on viruses" by E. Pollard; "The chemical constitution of viruses" by C. A. Knight; "Electron microscopy of viruses" by R. C. Williams; "The hydration of viruses" by M. A. Lauffer and I. J. Bendet.

Volume III includes "Comparative biochemistry and virology" by S. S. Cohen; "The chemotherapy of viruses" by R. E. F. Matthews and J. D. Smith; "Tumor viruses" by J. W. Beard, D. G. Sharp and E. A. Eckert; "Morphology and development of insect viruses" by K. M. Smith; "Multiplication of plant viruses in insect vectors" by K. Maramarosch; "Cross-protection between strains of yellows-type viruses" by L. O. Kunkel; "Current status of bacterial transformations" by H. Ephrussi-Taylor.

J. LEDERBERG

PRINCIPLES OF ANIMAL VIROLOGY.

By F. M. Burnet. Academic Press, New York. $10.00. x + 486 pp.; ill. 1955.

Burnet has long been the outstanding exponent of a biological conception of viruses and their relationships to animal disease. His work has had a singular impact in encouraging the rational study of viruses as organisms, starting with his leading studies on bacteriophage (which anticipated and anteceded a good part of contemporary research), continuing with pioneering applications of quantitative and enzymatic methods and culminating in the genetic recombinational analysis of the influenza virus. His influence has been mediated by a prolific output of technical articles and semi-popular books (*Virus as Organism*; *Natural History of Infectious Disease*). His current work as a more detailed and professional synthesis of the principles of animal virology is therefore certain to be warmly appreciated by his colleagues. Furthermore, he is quite right in stating in his preface that "an equally important function of scientific writing is to allow the manipulation of new knowledge into a form that will be useful to those not directly engaged in the special field concerned." As it is hard to name any field of biology or medicine for which an understanding of viruses would be wholly inept, the widest interest in a wholesome and critical synthesis of this kind should be expected and encouraged.

The work starts with an outline of the historical background of virus research, and then with a general summary of problems and principles, including an attempt to define *virus*. The sequence is quite appropriate, as it is only in retrospect that the facts needed for such a definition have become apparent. In seeking a definition, Burnet lays great emphasis on the occurrence of an eclipse phase, a noninfective stage in the intracellular development of the virus. This orientation may be related to his adoption of the view that the genetic content of a virus becomes dispersed in vegetative growth. This 'replicative subunit' hypothesis was widely current for a time among investigators of bacteriophage, but present information is equally compatible with the view that the vegetative virus merely lacks a protective coat and the apparatus for re-entering a host cell. The recent demonstration of the infectivity of the nucleic acid *per se* of the tobacco mosaic virus may furnish the means of deciding between these viewpoints, as well as of closing the unfortunate gap whereby "work on plant viruses has virtually no bearing whatever on animal virology."

The text of the book is about equally divided between considerations of the biology of the viruses, and of their biological setting in the host individual and host populations. The writing is always clear, straightforward and interesting, and the documentation selective but complete. While the methods of physical analysis have already permitted great strides in virology, Burnet does show a curious tendency to pessimism about the prospects of further understanding from these methods. "If a physico-chemical description of the basic property of replication of organic pattern is ever to be reached it is most likely to come from studies of virus replication. If, on the other hand as seems at present likely, it should emerge that there is virtually nothing that can usefully be described in terms of physical and organic chemistry and only isolated facets to be recorded in the language of enzymology, virus research may become the means by which new categories of interpretation may be introduced to biology." The most recent work on *in vitro* biosynthesis of nucleic acids (Ochoa, Kornberg) gives reason to hope that this is one of Burnet's rare errors of prevision.

Two exciting chapters are devoted to recent studies on the genetics of the influenza virus in the Melbourne laboratories. The technical difficulties of insuring the purity of clonal isolations are properly emphasized, but these notwithstanding, the evidence for genetic recombination in the progeny of mixed infections is entirely convincing. (Further work will doubtless take advantage of the plaque-counting and isolation techniques introduced by Dulbecco although, unfortunately, these are not yet applicable to influenza.) The study of recombination has led Burnet to present a new theory of the genetic determination of virulence, whereby special factors are capable of increasing or decreasing in number independently of the rest of the virus genotype. Some of the grounds for this departure from a more conventional interpretation are: the replicating subunit hypothesis for the intracellular growth of the virus; the fact that influenza virus contains RNA and may therefore follow a different genetic system from DNA viruses; the finding that a group of three markers (serological quality, heat resistance, and reactivity with sheep salivary mucoid) shows perfect linkage, while virulence for eggs and for mice is dispersively

inherited by recombinants; and the claim that dried virus, or recently mutated virus, must be passed several times before it manifests full, stable virulence. The last attribution, having a purely anecdotal character, is in deplorable contrast to the precision of most of Burnet's arguments, and in any case might equally readily be explained on the basis of natural selection in impure clones. While students of viruses, as of other organisms, should stay on the lookout for novel genetic mechanisms, the force of these chapters may be unfortunate for failing to give sufficient credit to an alternative chromosomal picture: the reviewer sees little in the experimental data that would be inconsistent with a conventionally polygenic control of virulence. In view of the manifold physiological bases of virulence, there seems no reason why this character should have a unique form of genetic determination. Are the three markers mentioned above really genetically distinct, or pleiotropic manifestations of a single mutational difference? In any case, are they sufficiently typical of the so-far unknown range of genetic determinants to support the argument that the virus is composed of a few inseparable linkage groups? The main difference between Burnet's and a polygenic determination of virulence is whether the numerous determinants multiply autonomously, or as part of the fixed genotype. For this reason, it is possible that further studies on the dynamics of virus growth, and of the genetics of other markers, may be prerequisite to a critical decision on the genetics of virulence. If Burnet's working hypothesis provokes generally a more detailed analysis of exaltation and attenuation of virulence (with due respect to populational effects), rather than to a too-facile explaining away of these obscure phenomena, the consequences may be more immediately important than the decision itself.

J. LEDERBERG

TOPLEY AND WILSON'S PRINCIPLES OF BACTERIOLOGY AND IMMUNITY. *Fourth Edition. Two Volumes.*

By G. S. Wilson and A. A. Miles. The Williams & Wilkins Company, Baltimore. $24.50, 2 vols. Vol. I; xii + 1106 + xlviii pp.; ill. Vol. II; x + pp. 1107–2331 + xlviii; ill. 1955.

It is almost enough to say that this standby of medical bacteriology has appeared in a new and revised edition. The familiar form of this handbook is preserved, and new material is added throughout. The authors have displayed very great diligence and acuity in amassing and selecting a tremendous amount of material; they begin to wonder themselves how much longer it will be possible. The general sections of the work on metabolism, general physiology, and genetics are well handled as far as they go, but they have to be covered so thinly that they may be less useful than the more particularly medical parts. This is the first place any practicing bacteriologist (and, hopefully, medical students) will go for a résumé of the literature on specific topics. The pressure of expanding factual knowledge has, however, forced the curtailment of material covered in previous editions; for example the complete Kauffman-White scheme (Salmonella serotypes) is no longer given, and this is presumably symptomatic of the authors' principal problem, to emphasize principles without ignoring details. On the whole, this is an encyclopedic rather than an interpretive work. The time when any person could give an integrated viewpoint, in detail, on medical bacteriology is probably past—more and current books of the genre of Dubos' *Bacterial Cell* are needed, but who could assimilate the detailed comprehension of genetic, biochemical, physiological and pathological approaches, over the full range of disease-related organisms, that would be needed for the task? This work is more than an accumulation of facts, and particularly in the areas of the authors' special interest (for example, but not exclusively, the immune response) the book lives up to its name, as the nearest approach to its objective in the English language.

One item of disappointment which may be enforced by the scope of the work, but perhaps could be remedied, is the carryover of ad hoc remarks, some of which are tantalizing but unsatisfying. For example (p. 128) "To recover dried organisms, an optimal medium is desirable for primary cultivation, and one or two subcultures may be necessary before the normal growth characters and virulence are restored" may be a true statement, but if so its documentation would be greatly desired as a basis for investigation of what might have to be a new genetic principle.

J. LEDERBERG

A LABORATORY MANUAL FOR IMMUNOLOGY.

By Henrik J. Stafseth, Jack J. Stockton, and John P. Newman. Burgess Publishing Company, Minneapolis. $3.00 (paper). ix + 73 pp.; ill. 1954.

This manual is designed for beginning students in a course having two 2-hour laboratory periods per week throughout a single quarter. It is based upon a course given at Michigan State University, and is prepared by members of the Department of Bacteriology and Public Health. The material covered is adequate, and is oriented toward the applied aspects of public health.

TISSUE CULTURE *As Applied, Especially Within Bacteriology and Immunology.*

By Ben Kimura. Ejnar Munksgaard, Copenhagen. Dan. Kr. 14.00 (paper). 273 pp.; ill. 1953.

Dr. Kimura is a Japanese bacteriologist and the present volume is largely an account of his and his collaborators' studies in tissue culture over the past 25 years.

The emphasis is largely bacteriological and immunological, but the results seem not to be particularly applicable to present-day research dealing with human and other mammalian tissues. It is, however, a sound progress report of the advances made in a somewhat limited area of tissue culture work.

THE MICROBE'S CONTRIBUTION TO BIOLOGY.

By A. J. Kluyver and C. B. van Niel. Harvard University Press, Cambridge. $4.00. x + 182 pp.; ill. 1956.

It is painful to record the recent death of Dr. Kluyver. It is fitting that he should have left this testament, and equally that it should have been in collaboration with van Niel, his one-time student and successor in the tradition of the "Delft School of Microbiology." The contribution which is implied by the title might as well have been called the contribution of these microbiologists: it is no less than the appreciation of the diversities of organic evolution, especially in chemical makeup and metabolism, but also in ecology and genetic structure. But more important, these diversities can be understood as variations on a recurrent theme. However, comparative biochemistry, like comparative anatomy, does not insist on the unity of living processes on detail: its existence depends on numberless alternative ways by which glucose can be metabolized, or in another sphere, by which genes can be recombined. On the other hand, if each organism were metabolically or genetically a law unto itself, we could have neither biology, as an academic science, nor any conception of the phylogenetic relationship of different organisms.

The book is a series of six essays, three by each author, which were prepared as the Prather Lectures at Harvard University. These chapters deal concretely with microbial metabolism, photosynthesis, physiological and genetic adaptations, and evolutionary patterns, and while rich in factual detail, they serve to illuminate the basic setting. The book is not recommended to the professional research microbiologist, who might quibble about advances of the past few years which may supersede some of the last minute details quoted in these essays. It will, however, delight the collegiate and general biological reader who will enjoy the skillful interweaving of microbiology and biochemistry with general biological principles.

J. LEDERBERG

ANNUAL REVIEW OF MICROBIOLOGY. *Volume 9.*

Edited by Charles E. Clifton; associate editors, Sidney Raffel and Roger Y. Stanier. Annual Reviews, Stanford. $7.00. x + 426 pp. 1955.

This series continues its well-known and well-received course. I am told that authors have been encouraged to follow their own inclinations in organizing their reviews. As usual, some of them are useful but tiresome bibliographic collections; others cover specific topics monographically and more interestingly. The editors are, of course, responsible for the policy of citing references by number; the reviewer is grateful to the authors who have evaded this rule by mentioning the worker's name too, and saving the need to refer constantly to the numerical list for identification of each attribution. This number includes the following topics: Taxonomy—Buchanan; Virus morphology—Bang; Genetics—Zelle; Growth dynamics—Novick; Nutrition—Stokstad, Broquist and Sloans; Metabolism — Delwiche; Antibiotics — Eagle and Saz; Psittacosis and Lymphogranuloma — Weiss; Plague — Girard; Coxsackie viruses — Dalldorf; Fungus infection of plants — Eide; Neisseria — Scherp; Radiation and infection — Talmage; Immunization — Edsall; Antigen-antibody reactions — Marrack; Spores — Schmidt.

J. LEDERBERG

METABOLISME DE *BACILLUS ROSEUS FLUORESCENS.*

By Robert A. Adams. Thèse, Université de Nancy, France. 107 pp. 1955.

Much interesting specialized work appears only in thesis form and escapes general attention, even by specialists in the field. This thesis deals with an organism (probably of the genus *Pseudomonas*) sometimes designated by the synonym *Bacillus bruntzii*. The production of its red, water-soluble pigment depends upon the presence of iron. The author considers that iron is also important in the production of other pigments by other bacteria.

WALTER C. TOBIE

BAKTERIOLOGISCHE NÄHRBÖDEN. *Ausgewählte Nährbodenrezepturen für das medizinisch-bakteriologische Laboratorium.*

By Lothar Hallmann. Georg Thieme Verlag, Stuttgart. DM 19.80. viii + 252 pp.; ill. 1953.

A standard handbook of bacteriological media and methods of preparation, based very largely on the Continental literature. It will be of interest chiefly to those who wish to compare American or British practice with that in use in Germany. Such new developments as Novick and Szilard's chemostat, for continuous maintenance of a bacterial population in the logarithmic growth phase, or the selective media for studying bacterial mutation are not included.

PETROLEUM MICROBIOLOGY. *An Introduction to Microbiological Petroleum Engineering.*

By Ernest Beerstecher, Jr. Elsevier Press, Houston and New York. $8.00. xvi + 375 pp.; ill. 1954.

Petroleum Microbiology is an important book because, so far as the reviewer is aware, it is the only book on the subject. Between one set of covers it brings together information previously scattered throughout the journals of a score of areas.

Following a dichotomous historical development of the petroleum industry and the science of microbiology, the discussion of petroleum microbiology is divided (in the fashion of engineering texts) into Exploration, Production and Manufacturing.

Exploration contains an absorbing account of the possible role of microorganisms in geological processes, e.g., in the formation of ferruginous deposits and in the biogeochemistry of sulfur and its compounds. The latest concepts of petroleogenesis are reviewed with some understandable bias toward the possible participation of microorganisms in the process. The weakest chapter in the book, and unhappily the very one which should provide the theoretical cornerstone for the volume, is "Microbial Utilization of Petroleum Hydrocarbons." Regrettably, the author has chosen to recount rather than to evaluate critically published work in the field. A biochemist of Dr. Beerstecher's stature could have performed a considerable service by a careful analysis of such reports. At the present writing, apart from embellishments on early observations that a variety of microorganisms will grow at the expense of hydrocarbon substrates and (based on oxygen consumption) will oxidize hydrocarbons, little detailed knowledge of the processes involved in hydrocarbon assimilation is available. Such information as is available is largely speculative, and, due to the technical difficulties of working with hydrocarbons, is not always supported in full by the experimental data presented. It is, of course, no reflection on the author that this section has a paucity of hard fact—rather, it is testimonial to the relatively small amount of good investigation extant in mechanisms of microbial hydrocarbon utilization. Indeed, the author has probably put his literary finger on some of the reasons by suggesting that classically trained microbiologists are loath to enter investigations "where interest is slight, support tenuous and the likelihood of success unattractive." To this must be added that the necessary analytical tools for hydrocarbon analysis, vapor phase chromatography, mass spectrometry and infra-red spectroscopy have only recently come into general use.

The presence and chemical activities of microorganisms, drilling muds and petroliferous formations, as well as microbial contributions to corrosion, are covered in "Production." A look into the future is provided in the last section wherein the possible use of microorganisms as manufacturing tools for producing drugs and food from petroleum substrates is outlined.

The volume was primarily designed to acquaint petroleum engineers with microbiological principles so that considerable patience on the part of microbiologists is required in many places. Nonetheless the author is to be commended for presiding in such an interesting manner over the union of two such diverse fields.

R. E. Kallio

PARASITOLOGY

A Manual of Parasitic Mites of Medical or Economic Importance.

By E. W. Baker, T. M. Evans, D. J. Gould, W. B. Hull, and H. L. Keegan. A Technical Publication of the National Pest Control Association, New York. $4.25. vi + 170 pp.; ill. 1956.

During the past ten years, more and more parasitologists, medical entomologists, physicians, veterinarians, pest control specialists, and others have been forced to deal with problems concerned with mites. Baker, who is the acarologist with the U. S. Department of Agriculture, is the man from whom most of these people attempt to gain information. In an effort to be of greater service, by making the answers to the most frequently asked questions more available, Dr. Baker asked Evans, Gould, Hull, and Keegan to cooperate with him in writing *A Manual of Parasitic Mites of Medical or Economic Importance.* The National Pest Control Association cooperated by publishing the Manual.

The Manual contains figures and descriptions of all the mites that commonly parasitize or bite man, his domestic animals, and his pets, including those that are vectors of disease. The life cycle, bionomics, and control of most species are also discussed. The Manual contains a key to the species that are discussed in it, but as with all keys that cover only a few species of a large group of animals, it can be used only as a guide to which section of the book should be consulted to find out more about the specimens in question.

The book will be useful to specialists as a ready review of the information available about species that are most frequently referred to them by physicians, veterinarians, pest control operators, house-holders, and others. For the individuals who have occasional problems with parasitic mites, such as medical entomologists and parasitologists, the Manual will answer most of their questions. The information is presented in concise form and references to the more important or more recent publications on each species are given. A systematic and subject index is included.

G. W. Wharton

HEALTH AND DISEASE

Annual Review of Medicine. *Volume 7. Edited by David A. Rytand; associate editor, William*

Creger. Annual Reviews, Stanford. $7.00. viii + 611 pp. 1956.

This volume, like the previous ones, lives up to its resolutions (1) to provide critical survey of all fields of medicine, not mere enumerations of articles published, and (2) to level these surveys primarily at those in academic medicine. Twenty-five articles, each of about 20 pages, are included. Everything from obstetrics to psychiatry is covered. Judging particularly from those fields with which I am most familiar and therefore competent to say, I find the reviews authoritative. Particularly worthy of citation is the "annotated list of reviews in medicine" by the McKays which has appeared in each volume. This refers one very nicely to definitive articles in various fields appearing during the year reviewed. For the medical school teacher who is called upon to direct students to journal articles on topics somewhat outside his main field of interest, this annual list, I have found from actual practice, can be valuable.

VICTOR A. MCKUSICK

THE CONTRIBUTION OF ATOMIC ENERGY TO MEDICINE. *Hearings before the Subcommittee on Research and Development of the Joint Committee on Atomic Energy. Congress of the United States. Eighty-Third Congress Second Session on the Contribution of Atomic Energy to Medicine, June 2, 3, and 4, 1954.*

Atomic Energy Commission, Washington. (paper). iv + 194 pp.; ill. 1954.

This report, arising in a joint congressional committee, has as its purpose the presentation in open meeting of the progress made in medicine through the use of atomic energy. It is, therefore, a report of the research worker to those who provide him with the wherewithal to do the research. Most investigators will be familiar with the findings herein reported, but the transcription of the discussion will at least give the reader an idea of how a congressional group operates, and to what extent it can handle technical information in an intelligent manner. The reader will have to be the judge in this instance.

ENFERMEDADES INFECCIOSAS Y PARASITARIAS. *Tomo I, II.*

By Jose Ink. Lopez & Etchegoyen, S. R. L., Buenos Aires. Encuad. $500. (I) xvi + 884 pp. + 6 pl.; text ill. (II) xiv + pp. 885–1485 + 1 pl.; text ill. 1953.

A comprehensive treatise in the Spanish language of infectious and parasitic diseases. Each disease is discussed in regard to such aspects as its etiology, pathology, pathogenicity, immunity, clinical aspects, diagnosis, prognosis, complications, treatment, epidemiology, and prophylaxis. Medical writers interested in comparing similar treatises in the English language with those used in South America will be interested in this work.

CHEMOTHERAPY OF INFECTIONS.

By H. O. J. Collier; foreword by Alexander Fleming. John Wiley & Sons, New York. $4.00. xvi + 248 pp.; ill. 1954.

It is difficult today to visualize medicine without its arsenal of antibiotics, but it was only in 1941 that the chemotherapeutic properties of penicillin were demonstrated. Today penicillin is but one of many agents used in the combat of diseases, and the great hope of research workers in cancer is that the success of antibiotics in the treatment of bacterial diseases can be somehow repeated at the level of the malignant cell. The same thought also applies to the treatment of those diseases having a viral vector. The present book treats of chemotherapy as it relates to the infectious diseases, and among the topics discussed are the mechanism of action of some antibiotics, their usefulness in combating specific diseases, and a consideration of the most useful of the antibiotics as contrasted with the sulphonamides. Adequate bibliographies are given at the end of each chapter.

GAIGER & DAVIES' VETERINARY PATHOLOGY AND BACTERIOLOGY. *Fourth Edition.*

By Gwilym O. Davies. Baillière, Tindall & Cox, London; [The Williams & Wilkins Company, Baltimore]. $9.00. viii + 803 pp.; ill. 1955.

It was first with a mind to comparing this with textbooks of human pathology that I read this book. Several features stood out. Compared to texts of human pathology a seemingly inordinate portion of the book was devoted to infectious diseases. Obviously these are of greater importance to veterinary medicine than degenerative conditions. In the second place I was eager to find out what analogs of human disease exist in animals. In this connection the book is a disappointment. Mitral stenosis, dissecting aneurysm of the aorta and many other conditions are briefly described, possibly by direct reference to texts of human pathology, and with no indication of how frequently the condition occurs in animals, what species it is found in, and what articles have been written on the subject. The book may be useful for acquainting veterinary students with the rudiments of pathology. It is not a scholarly production, however, and will be of no value to comparative pathology. More intercourse between medicine and veterinary medicine, at the academic level at least, is desirable. It is significant that Bernhard Bang (1848–1932) graduated in medicine and worked in pathology and on the wards for

seven years before studying veterinary medicine (Bull. Hist. Med. *28:* 60, 1954). Auguste Chauveau (1827–1917), great veterinarian of France, became an M.D. *honoris causa* and president of the Academy of Medicine because of his appreciation of medical problems and significant collaboration with medical confrères (Scientific Monthly, 1957).

VICTOR A. MCKUSICK

SUBACUTE BACTERIAL ENDOCARDITIS. *American Lecture Series. Pub. No. 274.*

By Andrew Kerr, Jr. Charles C Thomas, Springfield, Ill. $6.50. xviii + 343 pp.; ill. 1955.

This is an excellent job of collecting in one place the voluminous recorded experience with this disease. The author states in the preface: "No attempt at a comprehensive review of the world literature on subacute bacterial endocarditis has been made." In view of his 800 references one wonders what a truly comprehensive bibliography would total.

There are occasional bits of phraseology which in the reviewer's opinion are unfortunate, but in general the book is well-written and is sound clinically and pathologically. The historical introduction is a pleasing feature.

VICTOR A. MCKUSICK

LABORATORY TECHNIQUES IN RABIES. *World Health Organization Monograph Series No. 23.*

Contributors: D. d'Antona, P. Atanasiu, R. Béquignon, E. Falchetti, Karl Habel, George A. Hottle, Harald N. Johnson, Martin M. Kaplan, A. Komarov, Hilary Koprowski, Pierre Lépine, Thomas F. Sellers, Ernest S. Tierkel, and C. Vialat. World Health Organization, Geneva; [Columbia University Press, New York.] $4.00 [£1 5s.; Sw. fr. 16.–]. 150 pp. + 1 pl.; text ill. 1954.

Prepared by 14 leading authorities on rabies, this handbook, which includes sections on Laboratory Diagnosis, Methods of Vaccine Production, Vaccine Potency Tests, the Production of Hyperimmune Serum, and Laboratory Animals used in rabies work, will undoubtedly remain for a long time the most indispensable reference for any biologists whose work is related to rabies. It is beautifully printed and illustrated, and its limp leatherette binding looks very practical for rough usage in the laboratory.

MAN'S MASTERY OF MALARIA. *Univ. of London Heath Clark Lectures, 1953, delivered at The London School of Hygiene and Tropical Medicine.*

By Paul F. Russell. Geoffrey Cumberlege, Oxford University Press, London, New York, and Toronto. $6.00. xvi + 308 pp. + 25 pl. 1955.

This book is a superb short history of our knowledge of malaria. The author remarks that he hesitated to write yet another book on malaria, but decided that recent advances have been so spectacular that it would be impossible to write a dull book about them. That is certainly true, but Russell treats his subject historically and makes the most ancient aspects and discoveries as interesting as the most recent. The book is divided into five sections on Aetiology, Therapy, Prophylaxis, International Aspects of Malaria, and Malaria and Society. The first three sections thus represent a standard history of malaria as a purely medical problem, while the last two are pertinent to the special challenge of malaria as a world wide public health problem. The reviewer was startled by the last chapter "Malaria Prophylaxis and Population Pressure" in which the author bluntly examines the question, which he quotes from Sir Charles Galton Darwin, "Is the world better for having a large number of healthy people dying of starvation, rather than letting them die of malaria?" He sharply disagrees with our current pest of naive neo-Malthusians and makes the cogent observation that we are not faced with a dilemma but with a problem, which is an entirely different matter. He further observes that "when the physician and sanitarian forsake that fundamental principle, the preservation of human life, they go adrift in dangerous waters."

PAUL CRANEFIELD

TUBERCULOSES OCULAIRES ET TUBERCULOSES PARAGANGLIONNAIRES. *Étude Phtisiologique et Applications Thérapeutiques.*

By L. Paufique, J. Brun, and P. Bonnet. Masson & Cie., Paris. 1,350 fr. (paper). iv + 183 + ii pp.; ill. 1953.

This monograph is directed to the clinician, but will be of interest to pathologists and diagnosticians as well. The radiologist will also be concerned with the assembled material on the radiotherapy of ganglionic and paraganglionic tuberculosis. The volume lacks an index.

A HISTORY OF THE THERAPY OF TUBERCULOSIS AND THE CASE OF FREDERIC CHOPIN. *Logan Clendening Lectures on the History and Philosophy of Medicine. 6th Series.*

By Esmond R. Long. University of Kansas Press, Lawrence. $2.00. viii + 71 pp. 1956.

The first part is a contribution to the study of the illnesses of the great and near-great—an account of Chopin's fight with tuberculosis from about 1835 to

his death in 1849. He was born in 1810. There are interesting statements made. Some the reviewer is prepared to believe, some not. "We may note that in 1835 hemoptysis was not yet considered a pathognomonic sign of tuberculosis." Keats, who died in 1821, said on spitting blood: "Bring me a candle—let me see that stain. It's arterial blood. That is my death warrant." Although in France and England tuberculosis was considered a degenerative disease, in Italy and to some extent in Spain its contagious nature was generally accepted not only in the medical profession but also by the public. While on the island of Mallorca, Chopin could not rent a closed carriage and his landlord billed him for the price of his mattress, which he said he would be obliged to burn. Keats had had similar problems in Italy. Sir James Clark, physician to Victoria and leading English phthisiologist of the day, condemned the practice he saw in Rome of having separate hospital wards for consumptives. He called it absurd and "due to the obsolete idea of consumption being contagious." Clark treated Chopin in England, and in France, Louis, famous for introducing the statistical approach to clinical problems, and Cruveilheir, famous mainly as a pathologist but also a practitioner, treated Chopin. The best thing that can be said for the treatment is that it was humane and gentle and that the patient was protected from the barbarous bleeding and purging still prevalent at the time.

The second portion of the book reviews the history of the treatment of tuberculosis from the days before the royal touch to the recent days of hydrazine derivatives of isonicotinic acid.

VICTOR A. MCKUSICK

CLINICAL ENDOCRINOLOGY *for Practitioners and Students. Second Edition.*

By Laurence Martin and Martin Hynes; foreword by Lionel Whitby. Little, Brown & Company, Boston. $5.50. x + 253 pp.; ill. 1954.

This volume is written for the practicing physician or for the student who has such a career in mind. It is therefore oriented toward diagnostic purposes, but in every instance whatever evidence is available is clearly indicated and evaluated. The first edition of this book appeared six years ago, and the present edition brings the treatment of the subject up to date.

PERIPHERAL NERVE INJURIES. *Med. Research Council Special Report, Ser. No. 282.*

Edited by H. J. Seddon. Her Majesty's Stationery Office, London. £2 15s. xvi + 451 pp. + 8 pl.; text ill. 1954.

Nerve injuries are, of course, enormously multiplied during periods of strife, and in World War II in Britain the casualties were both civilian and military. The British had published a report similar to the present one after World War I, and the value of it was responsible for the establishment of five nerve injuries centers in the early 1940's. This report deals with their findings as judged from case studies, and involves clinical features, recovery, operative treatment, electrotherapy and grafting. Both the clinician dealing with lesions which might involve the nerve tracts and the neurologist will find this volume of interest and importance.

COLD INJURY. *Transactions of the Second Conference, November 20 and 21, 1952, New York.*

Edited by M. Irene Ferrer. The Josiah Macy, Jr. Foundation, New York. $4.00. 242 pp.; ill. 1954.

The second conference on cold injury held by the Josiah Macy Foundation consisted largely of three rather lengthy presentations of research by L. M. Schuman, L.-P. Dugal, and J. Adams-Ray, together with the commentaries of eight guest contributors. The subject gains its importance from the frequency of frostbite among service personnel in areas such as Korea, Alaska, and more recently in Antarctica, as well as from the usefulness of hypothermia as a device for medical treatment. The further north a physician might be, the more useful would the volume be for purposes of diagnosis and treatment.

YOUR BLOOD PRESSURE *and How to Live with It.*

By William A. Brams; illustrations by Hertha Furth. J. B. Lippincott Company, Philadelphia and New York. $2.95. 160 pp.; ill. 1956.

This book is well-written by an experienced and well-informed physician. It points out that hypertension is an exceedingly common difficulty and only in the exceptional case pursues a course beset by complications leading to early and fatal issue. He also emphasizes that low blood pressure is, in most instances, a blessing, not a disease. Optimum weight charts and reducing diets are provided in the appendix. In this book for the layman the author goes into more detail about the determination of renal and cardiac function and of blood pressure, the varieties of hypertension, and causative factors than might, on first thought, seem wise to physicians. On closer analysis most will agree that in these days when the ill man-on-the-street refuses to be kept in ignorance about his illness, the details in this book are warranted. Brams has done a good job.

VICTOR A. MCKUSICK

LIFE STRESS AND ESSENTIAL HYPERTENSION. *A Study of Circulatory Adjustments in Man.*

By Stewart Wolf, Philippe V. Cardon, Jr., Edward M. Shepard, and Harold G. Wolff. The Williams & Wilkins Company, Baltimore. $7.50. x + 253 pp. ill. 1955.

This is a monograph reviewing the results of a psychologic-physiologic investigation of circulatory disease conducted at Cornell-New York Hospital by several members of the Department of Medicine with strong psychiatric leanings—psychosomatists, if you will. There is interesting material, presented often, however, with loose and superfluous verbiage. An unfortunate introductory paragraph sets the book off on the wrong foot with the reader accustomed to tightly written scientific communications. The first sentence ends as follows: "... its vessels penetrate virtually every organ, provid(sic) intercommunications among certain organs and serve to integrate their activities." Being unable to think of any organ not penetrated by the blood vascular system, the reader was forced to conclude that this was another example of abuse of the word "virtually." The last sentence of the first paragraph is ambiguous and this inexact writing is irritatingly frequent throughout. The chapter entitled "The Ballistocardiograph" seems to serve no useful purpose; this would seem scarcely the place for reviewing the literature and current status of this field.

On the positive side two features are particularly interesting: 1) the relationship of the development of attacks of cardiac dysrhythmia to emotional disturbance—often in apparently structurally normal hearts and often major varieties of dysrhythmia, such as atrial fibrillation and even ventricular tachycardia; 2) the novelettes represented by the detailed accounts of the lives of individual hypertensive patients spiked with a tasty amount of particulars about the patient's love-life.

It may be useful to the student of hypertension to have the results of the study, much of which has been published in the regular journals, collected between two covers.

VICTOR A. MCKUSICK

KWASHIORKOR.

By H. C. Trowell, J. N. P. Davies, and R. F. A. Dean. Edward Arnold, London; [The Williams & Wilkins Company, Baltimore]. $10.00. xii + 308 pp.; ill. 1954.

Kwashiorkor is a nutritional disease which is prevalent among many of the black tribes of Africa, where the name originated, but it is probably of worldwide occurrence since its basis is malnutrition. It is most commonly found in children, but is apparently not confined to them; in adults it appears to be caused by protein deficiencies. This book is a report of its prevalence, pathology, and response to treatment, together with a consideration of the basic cause or causes.

NUTRITIONAL FACTORS AND LIVER DISEASES. *Ann. N. Y. Acad. Sci., Vol. 57, Art. 6.*

Edited by Roy Waldo Miner; consulting editor, Klaus Schwarz; 59 contributors. New York Academy of Sciences, New York. $4.50 (paper). Pp. 615–962; ill. 1954.

This volume represents one of the largest of the numerous symposia held by the New York Academy of Sciences. After an Introduction by Klaus Schwarz on Liver Necrosis versus Fatty Liver and Cirrhosis there follow 20 papers on the latter and 16 on the former. Some of the numerous topics discussed in relation to fatty liver and cirrhosis are the lipotropic factors; the role of vitamin B_{12}; chronic choline deficiency; the dietary effect of bentonite; the effect of aureomycin on the blood lipid level in dogs with ligated pancreatic ducts; kwashiorkor—its epidemiology, pathology, clinical treatment, vitamin E and carotenoid plasma levels; enzyme activity in fatty livers of infants; the relative importance of protein and labile methyl groups in the development of the condition in man and in rats; protein metabolism in cirrhosis; the treatment of infantile cirrhosis with antibiotics; metabolic and nutritional patterns in alcoholism; and the genetotrophic concept. Topics covered in the section on Liver Necrosis included the pathology; dietary methods for inducing it experimentally; influence of the endocrine glands; protective factors; enzyme abnormalities; xanthine oxidase and molybdenum; tocopherol metabolism; phospholipid synthesis; antibiotics in relation to liver injury; liver necrosis in germ-free animals; hepatic injury from conditioned sulfo amino acid deficiency; and the clinical evaluation of a high-protein, high-carbohydrate, restricted-fat diet in treating viral hepatitis. The result is a comprehensive and authoritative picture of a highly important aspect of disease.

ADVANCES IN CANCER RESEARCH. *Volume III.*

Edited by Jesse P. Greenstein and Alexander Haddow. Academic Press, New York. $8.50. viii + 369 pp.; ill. 1955.

This is the third volume in a series to bring up to date many of the important contributions to cancer research. The contributors are outstanding authorities in their several fields from France, Italy and the United States. This series is exceedingly important for the cancer researcher and therapist, and for other students of the riddle of cancer.

Volume III contains several chapters on each of the following subjects: Etiology of Lung Cancer; The Experimental Development and Metabolism of Thyroid

Gland Tumors; Electronic Structure and Carcinogenic Activity and Aromatic Molecules—New Developments; Some Aspects of Carcinogenesis; Pulmonary Tumors in Experimental Animals; and Oxidative Metabolism of Neoplastic Tissues.

Not only are these subjects thoroughly and scientifically discussed, but rather extensive bibliographies are given for benefit of the student who wishes to continue his study more completely. This volume is a very important contribution to the literature of cancer research.

GRANT E. WARD

CANADIAN CANCER CONFERENCE. *Volume I. Proceedings of the First Canadian Cancer Research Conference, Honey Harbour, Ontario, June 16–19, 1954.*

Edited by R. W. Begg. Academic Press, New York. $8.80. xii + 443 pp.; ill. 1955.

This is the proceedings of the First Canadian Cancer Research Conference held at Honey Harbour, Ontario, June 16–19, 1954. The chief purpose of this conference was to bring the cancer investigators of Canada together for their mutual benefit and stimulation. These investigators are supported by The National Cancer Institute of Canada assisted by the Canadian Cancer Society and Federal-Provential grants.

Intentionally, the subject matter for this conference was arranged so that one day should be assigned to a particular subject. Also short and longer major papers were interspersed. Five main subjects were discussed by authorities of note in their various fields from Canada, the United States and Europe.

The main subjects are Experimental Tumors, Tumor-Host Relations, Informal Discussion on Cancer of the Lung, Enzymes, and Ionizing Radiations. These subjects are carefully reviewed by several authors in such a manner as to be of stimulating benefit to the researcher in cancer. Many references are given. Not much original work is presented.

This is an excellent reference and review volume.

GRANT E. WARD

ONE IN SIX. *An Outline of the Cancer Problem.*

By I. Hieger. Allan Wingate, London. 12s.6d. (paper). 80 pp. + 15 pl.; text ill. 1955.

This little book of 80 pages, including a Glossary, is written by one of England's foremost researchers in the field of cancer. It is an excellent résumé of cancer research and the theories of the causes of this dread disease. Many tables are used to illustrate the changes in cancer death rates in the past 50 years and factors influencing these changes.

The book is clearly written in simple terms which are readily understood by layman, student and those beginning the study of cancer. It gives a brief and concise picture of the present state of our knowledge of the subject. Statistics are taken from reports from many countries. The volume is an important and valuable one. I recommend it, especially as an introduction to the study of cancer.

GRANT E. WARD

THE LIVER AND CANCER. *A New Cancer Theory.*

By Kaspar Blond; with a foreword by E. Stanley Lee. John Wright & Sons, Bristol; [The Williams & Wilkins Company, Baltimore]. $6.50. xii + 220 pp. 1955.

The thesis of this book is the author's theory of the cause of cancer. He offers much argument, many times by analogy, and numerous examples to support his theory. It is clearly stated that his theory is not proved but that "confirmation must be left to future research." To understand this book better one should read, The Liver: Porta Malorum by the author and D. Haler, published by John Wright and Son, Bristol.

The theory is based on the hypothesis that cancer is a nutritional disease. Blond believes that all cancer is due indirectly to liver damage. This causes portal hypertension with consequent increase in calibre of the porto-caval shunts and a reversal of the blood flow in the portal system. "The liver is the chemical factory of the body, responsible for the assimilation of foreign proteins, fats, sugars and vitamins, the detoxication of chemical poisons, and the removal of waste products." When the blood flow in the portal system is slowed or reversed the "nutritional toxins" absorbed from the intestines pass into the general circulation without first being detoxified in the liver. These "nutritional toxins" then being carcinogenic cause cancer. It remains to be proved whether these "toxins" cause cancer and whether there is liver damage in all patients with cancer.

His arguments run about like this one. 80% of adult male population in the U.S. who die of cancer have cancer of metabolic organs, i.e., gastro-intestinal tract, pancreas, liver and bile ducts. 90% of all malignancies in children originate outside metabolic organs. Ante partem the liver and metabolic organs are not used. Detoxication is carried on within the mother. In other words, the circulation in the fetus determines the distribution of cancer in children. Post partum toxins enter the gastro-intestinal tract and are detoxicated by the liver. When the liver becomes damaged, the stomach, intestines and other organs are congested with blood containing unchanged or non-detoxicated toxins, and these cause cancer.

Also Blond holds that irritants such as tar when painted on the skin do not directly cause cancer but damage the liver and then cancer develops. Sixty percent of such experimental animals die of liver damage

before cancer develops; 40% live with liver damage and some have cancer of the skin. In other words, external irritants are not carcinogenic but "hepatopathogenic."

Blond throws out heredity, infections and viruses as factors in cancer etiology, and rejects Cohnheim's theory of embryonic cell rests. He also refutes and denies Virchow's cellular theory and Bauer's mutation theory, adding that too much attention has been given to study of cellular characteristics and behavior in cancer research and not enough to environmental influences. He also denies that early diagnosis and surgery will cure cancer for cancer is a generalized disease.

Blond holds that "Cancer distribution is a vascular problem" and that the calibre of porto-caval shunts is primarily responsible for number and sites of metastases.

Blond's theory is provocative of much thought. He holds that syncytium cells are carried to the liver through porto-caval shunts and suggests an animal experiment to support his theory. "An anastomosis between a branch of the portal tree carrying metabolites to the liver not yet detoxicated, and between one of the bigger branches of the vasa efferentia of the pregnant uterus of the animal, could offer the crucial proof for the origin of chorionepithelioma."

Much work needs to be done to prove or disprove Blond's theory of the relation of the liver to cancer. Some of his arguments are quite convincing and others contain wide gaps to be filled. In some areas it is difficult to follow his line of reasoning. His theory is impressive enough to warrant careful study.

GRANT E. WARD

HISTOLOGISCHE GESCHWULSTDIAGNOSTIK. *Systematische Morphologie der Menschlichen Geschulste als Grundlage für die klinische Beurteilung.*

By A. v. Albertini. Georg Thieme Verlag, Stuttgart; [Intercontinental Medical Book Company, New York]. DM 98.40; $23.40. xvi + 544 pp.; ill. 1955.

This book is a well written and illustrated description of the histological characteristics of the benign and malignant tumors of man. It follows in the classic tradition of Borst and Ewing and resembles the more recent *Pathology of Tumours* by Willis. As such it will be of considerable value to readers of German, but because it presents few new facts or interpretations there will be little need for others to refer to it.

Although intended primarily as a histological study of tumors, a correlation of tissue pattern with cytological detail would have added greatly to the value of the book. Pathologists are giving ever increasing attention to cell morphology in order to avail themselves of current progress in the field of exfoliative cytology. Brief mention is made of sputum examination for exfoliated tumor cells in cases of suspected lung cancer. However, no consideration is given to the use of this technique in cervical cancer, where the method has proven of great value in the early diagnosis of one of the most common malignant tumors of women.

The book is adequate to its task of describing most of the more common tumors, but omits those of the central nervous system. Oncologists will not find reference to many of the rare neoplasms; precisely the ones about which they might wish additional information. However, the book can be recommended to students and clinicians as a sound treatise on the microscopic morphology of the tumors they will encounter in practice.

HANS G. SCHLUMBERGER

CANCER CYTOLOGY AND CYTOCHEMISTRY. *Ann. N. Y. Sci., Vol. 63, Art. 6.*

Edited by Roy Waldo Miner; consulting editor, M. J. Kopac; 49 contributors. New York Academy of Sciences, New York. $4.50 (paper). Pp. 1033–1462; ill. 1956.

The papers presented at this conference on cancer cytology reflect two major factors in the rapid advances being made in the field; viz, the rise of "exfoliative cytology," and the development of new physical and chemical techniques. Exfoliative cytology is concerned with the examination of cells found in smears usually prepared from secretions obtained at various body orifices. About half of the 35 papers deal with various aspects of this problem, particularly the cytologic criteria of malignancy in exfoliated cells of the uterine cervix, endometrium, lung, gastrointestinal tract, and breast. These presentations are largely re-evaluations of data already quite well known. Two papers describe automatic scanning devices for recognizing the presence of cells suspicious of malignancy in smears of exfoliated cells.

Among the cytochemical studies are several outstanding articles, including one by Hsu and Moorhead on chromosome anomalies in human neoplasms and another by Mellors on nucleic acids and proteins in the mitotic cycle of normal and neoplastic cells. Among newer techniques discussed are soft x-ray methods, electron microscopy, and the color-translating ultraviolet microscope. In a discussion of subcellular transplantation Kopac describes several of the newer methods, including a volumetric sub-micromanipulator and a television-micromanipulator.

The bibliographies are extensive, and the illustrations are of superior quality. This volume offers the reader an excellent over-all view of current research in cancer cytology.

HANS G. SCHLUMBERGER

METHODS IN MEDICAL RESEARCH. *Volume 6.*

Editor-in-Chief, J. Murray Steele. The Year Book Publishers, Chicago. $7.00. xvi + 271 pp.; ill. 1954.

This volume contains valuable aids to workers in a number of fields, but its very heterogeneity may keep it from being as useful as it should be, unless the existence of the series and the location of the various articles within its volumes become better known. Volume 6 contains 4 sections: Some Methods of Studying Human Genetics (A. Ciocco, editor; C. C. Li, contributor); Methods in Environmental Medical Research (R. G. Daggs, editor; 8 contributors); Statistics in Medical Research (D. Mainland, editor; D. Mainland and L. Herrera, contributors); and Design and Construction of Metabolism Cages (edited and chiefly written by A. Lazarow).

The articles on human genetics by Li emphasize methods for determining the segregation of recessive offspring, for determining the severity of an abnormality, for establishing the genetic role, and for distinguishing linkage versus association of hereditary characters. These are treated at a considerably more advanced level than Mainland's handling of medical statistics, which is aimed to supply neither a theoretical guide nor a handbook of methods for blind application, but rather an appreciation of "what modern biological statistics implies throughout the conduct of any type of medical investigation." Emphasis is laid on random sampling, on the planning and design of experiments and clinical trials, on the treatment (statistical) of the independent individual, and on confidence limits, sample sizes, and standards of significance. The treatment is extremely clear and, though elementary, is certain to be of great value to any workers in biological fields who are attempting to master the essentials of good statistical procedure through their own efforts.

The second section deals with Measurement of Climatic Variables (R. L. Pratt and A. Henschel); Respiratory Exchange (L. D. Carlson); Energy Metabolism and Metabolic Reference Standards (A. T. Miller, Jr.); Radiometric Methods for Measurement of Skin Temperature (J. D. Hardy and Alice M. Stoll); and Measurement of Sweating (S. Robinson and Aline H. Robinson). The topics thus range from physiological methods of great general usefulness to those of highly restricted applicability. The same may be said of Lazarow's descriptions of metabolism cages for rats, mice, and dogs. Appropriately, the methods for rat metabolism cages are described most extensively. A few comments by other workers are added.

The volume is well indexed, both by subject and by names of authors. Nevertheless, when all is said, would the several contributions not be better placed in volumes much less heterogeneous in character? For example, a volume containing Mainland's and Li's sections together with other material of a generally statistical methodology would be of greater service to particular users and more attractive to purchasers, while the strictly physiological methods might likewise be combined in a more appropriate way

BENTLEY GLASS

HEALTH FOR EFFECTIVE LIVING. *A Basic Health Education Text for College Students.*

By Edward B. Johns, Wilfred C. Sutton, Lloyd E. Webster; adviser and consultant, Walter H. Brown; foreword by Bernice Moss. McGraw-Hill Book Company, New York, Toronto, and London. $4.75. xviii + 473 pp.; ill. 1954.

The character of this textbook is sufficiently displayed in the headings of the six parts into which it is divided: Orientation in Health Education; Developing a Healthy Personality; Preparing for Effective Family Living; Developing and Maintaining Health; Building Defenses for Effective Living; and Effective Living in the Community. Probably 10 per cent good biology; 10 per cent good psychology; 20 per cent good sociology; 30 per cent propaganda like that ladled out from the elementary grades through the high school—how can they stand it any longer?—"brush your teeth, go to bed at a regular hour, stay away from drugs and stimulants"; and 30 per cent pure padding, e.g., "Physical education contributes to health education through health guidance in such student problems as conditioning, preventing infection, cleanliness, bathing, and adjusting to the opposite sex, to mention a few examples." The authors are in spots quite modern, as when they discuss Kinsey's findings about American sex practices and Kleitman's studies of sleep. They have given much useful information about diseases, about reproduction, about diet. Their points of view are generally sound. But does one really have to take a page to explain to a college student what a "medical doctor" is?

This textbook is a prize example of the emphasis on "life adjustment" that has watered down so much the level of college training in our country. It explains the critical need for the newly formed Council for Basic Education.

BENTLEY GLASS

NEEDED RESEARCH IN HEALTH AND MEDICAL CARE. *A Bio-social Approach. Based on a Seminar held in Chapel Hill in September, 1952.*

By Cecil G. Sheps and Eugene E. Taylor. The University of North Carolina Press, Chapel Hill. $5.00. xii + 216 pp. 1954.

The ability to predict research needs for the years ahead is at best a difficult problem, but it can perhaps be done in medicine with more chance of success than

it can in industry, education, or the basic sciences simply because it is clear that advances in medicine can be made at the sociological level without any further advances at all in the diagnosis, prevention, or treatment of disease. This book, which arose out of a seminar on "Needed research in health care" at Chapel Hill in 1952, is therefore an attempt to define those research needs which would help to take American medicine out of the laboratory and orient it toward the community at large. The object is the promotion of health, as distinguished from the mitigation or prevention of disease, and this of course involves many factors in a rather complex environment. The book, therefore, should be of interest not only to the public health official, but also to the sociologist, educator, and forward-looking citizen.

THE HEALTH OF REGIONVILLE. *What the People Thought and Did About It.*

By Earl Lomon Koos. Columbia University Press, New York. $3.25. xiv + 177 pp.; ill. 1954.

A professor of Social Welfare at Florida State University and his staff picked a representative town (in the hill country of New York State) and interviewed 500 families quarterly over the space of 4 years to find out their attitudes toward sickness. The families were grouped into 3 social-economic classes: business and professional people; skilled and semiskilled workers; and unskilled workers. Ignorance about the causes of disease and prejudice against hospitals were found to play an important part in preventing adequate health attention, particularly in familes of Group III.

THE MANUAL OF ANTIBIOTICS 1954–1955. *Preparations, Therapeutic Index, Generic and Trade Names, and Producers.*

Prepared under the editorial direction of Henry Welch. American Pharmaceutical Association, Washington. $2.50. 88 pp. 1954.

PSYCHOLOGY AND ANIMAL BEHAVIOR

SCIENTIFIC METHOD IN PSYCHOLOGY. *McGraw-Hill Series in Psychology.*

By Clarence W. Brown and Edwin E. Ghiselli. McGraw-Hill Book Company, New York, Toronto, and London. $6.00. xii + 368 pp.; ill. 1955.

In this book the authors have tried to provide "a systematic description of the use of the scientific method in studying behavior" and "to present the characteristics and concepts of the scientific method as a set of tools with which the student can embark on a serious attempt to learn about, and to experiment with, human behavior."

There are 15 chapters divided into three parts: Some general concepts about the scientific method, Steps of the scientific method, and Some individual scientific procedures. Examples are drawn from diverse fields of psychology to illustrate the principles discussed.

Telling someone else how to do good research is difficult, as any teacher of science knows. What the authors have tried to say in this book is good. Students of psychology should know it. Whether they will learn it is another matter, for the text is wordy and full of cumbersome grammatical expressions. The authors somehow never seem to get out of the clouds and down to the "brass tacks" of doing research.

A. CHAPANIS

PARENTAL AGE AND CHARACTERISTICS OF THE OFFSPRING. *Ann. N. Y. Acad. Sci., Vol. 57, Art. 5.*

Edited by Roy Waldo Minor and Leonell C. Strong (conference chairman); 22 contributors. New York Academy of Sciences, New York. $3.50 (paper). Pp. 451–614; ill. 1954.

One of the most frequently cited defects to appear among human offspring of older mothers is that of mongolism, but it is not the only change that appears to be correlated with age of the parent. An aging effect, expressed among the offspring, is known in almost all experimental animals, and can be found under certain circumstances in aged parts of plants, but it appears that the causal mechanisms are far from being obvious or even vaguely evident. The pattern of defects, whether genetically determined or not, is varied indeed, and it would seem that the best insurance that an offspring could ask of its parents is that its mother be young; the age of the male parent is of little consequence.

The 21 papers represent a conference held on January 23–24, 1953, and sum up a very diverse group of investigations on this particular aspect of the aging process.

PROBLEMS OF INFANCY AND CHILDHOOD. *Transactions of the Seventh Conference, March 23 and 24, 1953, New York.*

Edited by Milton J. E. Senn. The Josiah Macy, Jr. Foundation, New York. $2.75. 196 pp. 1954.

Following the general pattern of Macy Conferences, this one was focused on 4 presentations, as follows: Developmental Truisms and Their Fate in Child Rearing—Clinical Observations (Emmy Sylvester); Some Pathological Processes Engendered by Early Mother-Child Separation (John Bowlby); Clinical Observa-

tions on the Emotional Life of Children in the Communal Settlements in Israel (Gerald Caplan); and Observation of Individual Tendencies in the Second Year of Life (Katherine M. Wolf). The 20 participants and 7 guests entered into discussions of these and related topics, and this discussion is reported in extenso. An Appendix contains a Report of the Subcommittee on Rooming-In. This is the final Macy conference in the series. The inclusion of a Cumulative Index to all 7 volumes of the proceedings is sure to be most valuable.

INTRODUCTION TO THE PSYCHOLOGY OF MUSIC.

By G. Révész; translated from the German by G. I. C. de Courcy. University of Oklahoma Press, Norman. $4.00. xiv + 261 pp. + 2 pl. + 1 folded chart; text ill. 1954.

This work by a European psychologist, dedicated to his friend Béla Bartók, is a brilliant and fascinating achievement of versatile scholarship. Révész ranges from a consideration of the relationship between the physical nature of sound, the apparatus of hearing, and the musical tone to fundamental problems of the psychology of sound and of music. The chapter headings are sufficient to indicate the scope of the book: Dependence of Sound Perception on Physical Stimulus; Physiological Acoustics; The Human Voice; Basic Elements of Musical Tone; Theory of Intervals; The Consonance Problem; The Musical Ear; Key Characteristics; Relation between Tone and Colour Perception; Musicality; Musical Talent; Development of Musical Capacity; Inheritance of Musical Capacities; Creative Work; Receptive and Productive Musical Accomplishments of the Deaf; Pathology of Musical Perceptivity; The Origin of Music; and Aesthetics and the Psychology of Music.

No one could be authoritative and original, as well as complete, over so vast a range of science and art, history and philosophy; but everyone interested in music will find something new and stimulating in this volume, perhaps even in his own special area of competence. The reviewer, for instance, was unaware of two extremely interesting studies described by Révész of the inheritance of musical capacities. The legion of biologists, as well as physical scientists and psychologists, who find in music their chief relaxation and passion outside of their science, will each find this book the answer to a long-felt need. For the musician, a careful study of it is indispensable.

BENTLEY GLASS

THE PSYCHOLOGY OF MAN'S POSSIBLE EVOLUTION.

By P. D. Ouspensky. Alfred A. Knopf, New York. $2.50. xii + 114 pp. 1954.

Ouspensky deals, in the course of five lectures grouped here in book form, with the problem of man's ability to know himself as an acting machine, brought to a certain level of perfection by nature but capable of evolving to greater perfection by self-knowledge, self-development and self-determination of direction. His theme is that man can take over at a point where nature left off, but that to do this man must develop inner qualities and capacities of which he is now but dimly aware or even fails to recognize. Few would disagree with this point of view, but Benjamin Franklin summed this up more simply in *Poor Richard's Almanac:* There are three things extremely hard, steel, a diamond, and to know one's self.

THE SEXUAL OFFENDER AND HIS OFFENSES. *Etiology, Pathology, Psychodynamics and Treatment. I. Review of the Literature (1912–1951). II. Psychodynamics of Sexual Offenses and a Formulation of the Problem.*

By Benjamin Karpman. Julian Press, New York. $10.00. xxxvi + 744 + iii pp. 1954.

Dr. Karpman's very substantial book consists of two general sections. The first is essentially a review of the literature, grouped into 14 chapters and carefully summarized at the end of each chapter. Some 300 case studies are included in this analysis. The second section deals with his own views on the subject, arrived at through many years of clinical experience. Twelve chapters are devoted to various types of sexual abnormalities, the conclusions drawn are buttressed by first-hand clinical studies, and, as in the previous section, general summaries are provided at the end of each chapter. The book is terminated by a lengthy "psychogenic inventory," which is really the questionnaire which Dr. Karpman uses on his patients. The 312 questions cover most of the conceivable situations in which the sexual offender might be involved emotionally or physically, and which he can describe sufficiently well to provide the clinician with diagnostic clues.

SEXUAL DISORDERS IN THE MALE.

By Kenneth Walker and E. B. Strauss. Cassell & Company, London; [The Williams & Wilkins Company, Baltimore]. $3.75. xiv + 260 pp. + 1 pl. 1954.

NEUROLOGY AND PSYCHIATRY IN CHILDHOOD. *Proc. Ass. Res. nerv. ment. Dis., December 10 and 11, 1954. Volume XXXIV.*

Edited by Rustin McIntosh and Clarence C. Hare. Williams & Wilkins Company, Baltimore. $11.00. xii + 504 pp.; ill. 1954.

BIRD LIFE.

By Niko Tinbergen. Oxford University Press, New York; Geoffrey Cumberlege, London. $2.75. 63 pp. + 1 pl.; text ill. 1954.

Bird Life, the fourth volume in the *Oxford Visual Series*, dealing with subjects in the areas of physical and natural sciences, is an account of bird behavior based on first-hand observation. Many reasons may be advanced to justify bird-watching, but none is more convincing than the author's contention that birds are interesting and that observing them gives one great pleasure. His book is an attempt to interest the reader in observing birds and making discoveries about how they live. Among the topics covered are: how birds move about; feathers and plumage; eyesight and hearing; how birds get their food; how birds protect themselves; the habitats of birds; song; fighting; courtship; nest-building; incubation; watching various bird families; how birds rear their young; births and deaths; the diet of hawks; owls' pellets; how birds behave and learn. All of these topics are discussed lucidly and delightfully. Numerous sketches, photographs, and diagrams supplement the text. No one who picks up this book can fail to become interested in birds. Whether the reader be young or old, layman or professional, he will enjoy every page. This is a book everyone should possess.

V. G. DETHIER

HUMAN BIOLOGY

PHYSIOLOGIE GÉNÉRALE DIÉTÉTIQUE ET COMPORTEMENT DE LA VIELLESSE.

By R. de Crailly and H. Desfrew. Maisson & Cie. Paris. 1,500 fr. (paper). 265 pp. 1953.

This gerontological treatise consists of 3 parts, devoted respectively to the anatomical transformations connected with normal aging, the biochemistry of aging (brief), physiological changes during aging, the causes of aging (brief), aging in relation to atherosclerosis, rejuvenation, prophylaxis against aging, and the dietetics and regulation of life in the aged. The standpoint adopted is strictly that of human aging, and general biological aspects are not included. However, the authors have made a very thorough search of the literature and have assembled their information critically: witness a brief but effective disposal of Bogomoletz' rejuvenation by antireticulocytotoxic serum. The volume will be of special interest to gerontologists and other physiologists concerned with the aging process. The volume lacks an index, but the extensive Table of Contents may prove sufficient for most users.

CURRENT ANTHROPOLOGY. *A Supplement to Anthropology Today.*

Edited by William L. Thomas, Jr. The University of Chicago Press, Chicago. $5.00. xii + 377 pp. 1956.

This is a reprinting of contributions published in 1955 in the *Yearbook of Anthropology* (*Q. R. B.*, 31: 164. 1956). It makes accessible to readers all of these papers, handsomely printed, and bound in smaller compass. Readers of this review will probably be most interested in the Guest Editorial by Julian S. Huxley, Evolution, Cultural and Biological; Changing Man's Habitat: Physical and Biological Phenomena, by Paul B. Sears; Primatology in its Relation to Anthropology, by Adolph H. Schulz; Fossil Man and Human Evolution, by Loren C. Eisley; Old World Archeology and Prehistory, by Louriston Ward.

Only the fact that a review of these papers has already appeared in this journal accounts for this summary mention.

WILSON D. WALLIS

THE RACIAL AFFINITIES OF THE BAGANDA AND OTHER BANTU TRIBES OF BRITISH EAST AFRICA.

By Lawrence Oschinsky. W. Heffer & Sons, Cambridge. 25s. x + 188 pp. + 14 pl. + 1 folded table. 1954.

This is a physical anthropological study of an unusual sort, inasmuch as it combines the classical interest in body measurements and indices with the more recent tendency to base anthropological considerations on the frequencies of simply inherited genetic traits, such as blood groups. The Baganda and other Uganda Bantomorphs, according to the study of body measurements made by the author, cannot represent a mixture between the Congomorphic or Nigeromorphic Negroes, on the one hand, and the Hamitomorphs, such as the Batutsi, on the other. The autochthonous character of the Baganda and the related Bantomorphs is supported by the data of Lehmann and Raper on the frequencies of sicklemia, and by the blood group data of Elsdon-Dew and Pijper, which indicate a great similarity between the East African Bantomorphs and the South African Bantus. The blood-group data alone, are not, however, capable of giving a clear picture of relationships because there is often considerably greater heterogeneity between closely related groups than between such very different groups as the Congomorphs and the Nilotomorphs.

An extensive appendix contains not only tables giving the significance of differences according to the t test and a summary of the author's data, but also photographs of the Baganda and their relatives and tables summarizing Coon's data on Southern Arabia.

BENTLEY GLASS

LES GROUPES SANGUINS CHEZ L'HOMME. *Étude Sérologique Et Génétique.*

By Jaques Ruffié; preface by A. Tzanck. Masson & Cie., Paris. 1,200 fr. (paper). iv + 212 pp.; ill. 1953.

THE NEOLITHIC CULTURES OF THE BRITISH ISLES. *A Study of the Stone-using Agricultural Communities of Britain in the Second Millennium B. C.*

By Stuart Piggott. Cambridge University Press, New York. $13.50. xx + 420 pp. + 12 pl. + 1 folded table; text ill. 1954.

This volume, by a distinguished British archeologist, will be a boon to those who wish detailed knowledge of British Neolithic cultures. Accounts are given of all important stations, with an inventory of finds, and comparisons with other localities. Regional distributions and contacts are listed, and as far as possible, chronological sequences are noted. The task was no small one. Of chambered tombs, for example, there are about a thousand in Eire and Northern Ireland, 215 known ones in England and Wales, and 357 in Scotland. These various cultures, though to some extent distinctive of the British Isles, and even of a certain region within them, are allied with continental Neolithic cultures, particularly with those of Switzerland, France, and the Iberian Peninsula; and northern portions of the British Isles show affiliations with the earliest (Transitional) cultures of Scandinavia. In the Orkneys, a variety of cattle occurs which is different from that of southern regions: "The breed was uniform, but totally different from either *Bos longifrons* as known from Scottish Iron Age sites or from the southern English Neolithic breed, being noteworthy for the strongly contrasted male and female skulls and for the presence of the polled skulls of bullocks." In this island, sheep "of the slender Soay type with massive horns" were as frequent in the finds as were cattle. The pig was rare, and not domesticated.

All of the Neolithic cultures of the British Isles are assigned to the period of about 2000 to about 1500 B. C., with relatively small deviations of regions at one or the other of these dates.

There is an excellent index, and twenty-four pages of bibliography. One presumes it will long be a valuable book for reference.

WILSON D. WALLIS

INDIANS OF THE NORTHWEST COAST. *Anthropological Handbook Number Ten.*

By Philip Drucker. Published for The American Museum of Natural History, McGraw-Hill Book Company, New York, Toronto, and London. $5.75. xiv + 208 pp.; ill. 1955.

This is a summary account of tribes which live, or lived, "along the shores of northwestern North America from Yakutat Bay in southeast Alaska to Trinidad Bay on the coast of ... northern California." It is a culture referred to by anthropologists as the North American Northwest Coast area, rich in many ways, known best to the public, perhaps, for its gigantic totem poles and, for the northern portion of the area, its seagoing dug-out canoes, plank houses, and artistry in wood-work. Famous, too, is the potlatch ceremony at which goods are given away or destroyed, to enhance the owner's prestige, or to validate his claims to status or privilege.

It is the most inclusive and illuminating account of the area which has appeared, and will receive a welcome from students of the American Indian and others who are curious as to the manner in which man lives.

WILSON D. WALLIS

THE PRESENT STATUS OF THE ARCHEOLOGY OF WESTERN MEXICO: A DISTRIBUTIONAL STUDY. *University of Colorado Studies, Ser. Anthropol., No. 5.*

By Robert H. Lister. University of Colorado Press, Boulder. $3.00 (paper). xiv + 183 pp.; ill. 1955.

The archeological region described here includes all, or parts, of eleven western Mexican states. Published sources and museum collections are the main basis of information, supplemented by the author's field observations. The test is clear, concise, and unusually well illustrated; one can see, as he reads, the things described. Distribution maps indicate the localities in which various types of artifact have been found. The polychrome ware has high artistic merit. Nowhere in the New World was the wheel a technological device, yet in Mexico it was used on toys, two of which come from this region. Here also have been found ball courts at four sites—known elsewhere in the New World only in other parts of Mexico and in the Southwest United States. The non-specialist as well as the professional archeologist will be grateful for this comprehensive summary which brings to life the buried remains of cultures much indebted to certain other known cultures of nearby regions, yet in their totality unique.

WILSON D. WALLIS

THE ARCHEOLOGICAL AND PALEONTOLOGICAL SALVAGE PROGRAM IN THE MISSOURI BASIN, 1950–1951. *Smithsonian misc. Coll., Vol. 126, No. 2, Publ. 4188.*

By Paul L. Cooper. Smithsonian Institution, Washington. $1.35 (paper). iv + 99 pp. + 12 pl. + 1 folded map. 1955.

After plans had been made to build dams on the Missouri which would impound waters that must cover a vast amount of acreage, archeologists and paleontolo-

gists sought and obtained an appropriation to finance investigation of important sites that would be destroyed by these lakes. Cooper describes the work done, and the findings made, through the calendar years 1950 and 1951. In the Canyon Ferry area, near Helena, Montana, investigations yielded "numerous individuals of forms only scantily represented heretofore and a number of forms previously unknown for the area"; these were small mammals of Oligocene and of Miocene ages. "Two new Miocene fossil localities were discovered."

Sixty-six sites, widely distributed, were excavated. The report of these studies will be "a good beginning . . . toward filling the gap in our knowledge of cultural history in the area. . . . Perhaps the most impressive accomplishment of the investigations to date has been the revelation of the complexity of the region's archeology."

WILSON D. WALLIS

STUDIES IN CHEREMIS: THE SUPERNATURAL. *Viking Fund Pub. Anthropol., No. Twenty-Two.*

By Thomas A. Sebeok and Frances J. Ingemann. Wenner-Gren Foundation for Anthropological Research, New York. $5.00 (paper). 357 pp.; ill. 1956.

The Cheremis, numbering about a half-million, live "between the Volga and Vyatka Rivers to the northeast and northwest of the Volga bend, though a small remnant still exists on the right bank of the Volga where most of them were located formerly." The authors, of whom the first mentioned has made the Cheremis his special study, give a detailed account of manifestations of the supernatural as experienced by these people, of their priesthood, ceremonies, and rites. There is a listing of divinations and omens; a section treating of prayers; one on dreams; and one on charms. There is an account of the divagations of Christianity as it has been adapted to and adopted by the Cheremis, a Christian superstructure on a pagan base, but nevertheless a considerable blending of the two.

There is a detailed and highly entertaining account of a native cult, "nativistic movement," of recent fruitage, the "Big Candle."

The volume is replete with detailed and precise information in each of the topics, and is the only important English source for Cheremis ethnography. A perusal will profit any student of religion.

WILSON D. WALLIS

THE NAVAJOS.

By Ruth M. Underhill. University of Oklahoma Press, Norman. $4.50. xvi + 300 pp. + 16 pl. 1956.

Perhaps no group of primitive peoples, except the Eskimo, have been as much written about as have the Navajos. They occupy the largest region, and are the most populous of North American tribes. During the last hundred years they have experienced many vicissitudes. The region over which they roamed before the middle of the last century, "an expanse of desert, ravine, and table land," was the size of the combined areas of New Hampshire, Vermont, and Rhode Island. In 1869 they numbered above eight thousand, and owned about two thousand sheep and goats. In that year these flocks were augmented by fifteen thousand newcomers. By 1880 the twelve thousand people had flocks aggregating seven hundred thousand, and they had horses. By 1889 the people were twenty thousand, the flocks a million and a quarter, the horses five hundred plus a hundred thousand. A million pounds of wool were produced, and the handmade blankets brought fifty thousand dollars. By 1954 there was a human population of some seventy-five thousand. The horses were a luxury article, and a horse was eating as much as five sheep. The land was overgrazed, and the Navajos demanded more territory in which to raise more sheep and keep more horses, for they had acquired only an average of five horses per person. The grazing and the trampling of the sheep, goats and horses denuded the soil of its sparse vegetation, their hooves added to the damage, and these paved the way to the washing of the land into gulleys and canyons. The government tried to correct this unbalance by insisting that the people keep less sheep and of a breed more productive of wool; also, that they get rid of most of their horses. This ran counter to Navajo ideas of what makes life and living worth while. Meanwhile the government was investing millions of dollars in attempts to balance the economy, educate the Navajos, and improve their health.

This is only an item in the story of these people, a story told here from the earliest times of which anything is known about them down to 1954. It is well told, with the intimacy of an authority on Indian life who has long been acquainted with tribes in the Southwest United States and who knows the Navajos at first hand as well as through the voluminous pertinent sources.

WILSON D. WALLIS

CULTURE AND EXPERIENCE.

By A. Irving Hallowell. University of Pennsylvania Press, Philadelphia. $7.00. xvi + 434 pp. 1955.

This is mainly a collection of papers published by the author in various journals and books and includes three chapters not previously published. The author's main interest is in types of personality as related to the culture. The principal analyses and illustrations are taken from a group of Saulteaux (Ojibwa) on Berens

River, Manitoba, east of Lake Winnipeg, and from a group of Ojibwa in Wisconsin, at Lac du Flambeau. His accounts of the Berens River group contains much ethnography not otherwise recorded.

The volume contains probably the most intensive analysis of personality type in relation to culture, in the Manitoba group of Ojibwa, that has been published for any group. The various chapters are illuminating for psychological insight and for ethnographic details regarding personality.

WILSON D. WALLIS

NEW LIVES FOR OLD. *Cultural Transformation—Manus, 1928–1953.*

By Margaret Mead. William Morrow & Company, New York. $6.75. xxii + 548 pp. + 16 pl. 1956.

The intrepid traveler, anthropologist, "the versatile Margaret Mead," again returns from the far Pacific and again presents us with a volume recounting her experiences and recording her reflections.

In 1953 she went to Manus, an island of the Admiralty Group, north of New Guinea, to revisit a people whom she had studied in 1928–1929. The emphasis in the present account is on the changes during the twenty-five years. For the Manus, specifically for Peri village, on the south coast, where she resided, as indeed for much of the world, the changes in manner of life and thought have been tremendous. These simple folk had witnessed the retreat of Australian administrators, the occupation by Japanese, and the arrival of American armed forces. About a million Americans passed through the region. From them, Mead believes, natives learned one essential of democracy: respect for fellow-man irrespective of race; as the Manus phrase it: whether he is white, black, red, yellow, or green. After the American forces had left, Manus was a cultural and economic vacuum. This the natives attempted to fill by moulding themselves into American-like persons. For a time this venture was thwarted by the so-called cargo cult which was widespread in nearby islands. The cargo cult assured adherents that all material blessings would soon arrive, by vessel, or by airplane, if the people should destroy all native possessions, including magic paraphernalia. They obediently threw everything into the sea. All except the magic formulas possessed by one old man who had these in his head and could find no way of getting rid of them. A concomitant ethical code emphasized the brotherhood of man, the equality of woman, and the necessity of putting away all anger. Here, as in every society, ideals are not a precise index of practice. Even so, in Manus much has been changed to approximate more closely the pattern of American life—as they conceive it. But they are distraught; they do not know—who does?—how to attain their ideals. Some knowledge is not enough. The moral is, Mead thinks: drink deep, or taste not.

WILSON D. WALLIS

FOR A SCIENCE OF SOCIAL MAN. *Convergences in Anthropology, Psychology, and Sociology.*

Edited by John Gillin; by Howard Becker, John Gillin, A. Irving Hallowell, George Peter Murdock, Theodore M. Newcomb, Talcott Parsons, and M. Brewster Smith. The Macmillan Company, New York. $4.00. viii + 289 pp. 1954.

As the subtitle indicates, the interrelations of three fields of social-mental science are discussed. Each specialist discusses the influence of one of these disciplines on his own specialty.

Murdock treats of sociology and anthropology, and Becker, of anthropology and sociology; Parsons discusses psychology and sociology, and Newcomb, the converse. Psychology and anthropology is Hallowell's assignment, and anthropology and psychology falls to M. Brewster Smith. Thus they ring the changes, then change the rings. Most contributors treat the topic historically; Parsons and Newcomb, however, have handled theirs mainly in analytic and critical fashion. Especially revealing is Newcomb's analysis of the topic "culture." The editor contributes an opening chapter on "Grounds for a Science of Social Man," and closes the volume with "The Forward View." Excepting the chapter by Newcomb, there is no account of collaborations by representatives of these fields, or any indication of the kind of problems that could best be treated by collaboration. One would like to know what kind of collaboration they would suggest by way of answering, for example, the questions posed by Newcomb (p. 248): "What are the effects upon personality organization of being reared as an only son in a middle-class, urban, professional family in contemporary America? . . . How can we account for stability and change in the relationships between only sons of the kind described above, and their mothers?" In more than one instance a contributor assures us that he does not advocate abolishing specialties in any of these fields. "The present requirement for a unified science of man," Newcomb believes, "is not fusion of the different levels of inquiry, but recognition and understanding of what is identical and what is distinctive. From such recognition and understanding, theoretical integration may yet emerge" (p. 256). Gillin suggests that "the progress of all interests, whether of the 'pure' or the 'applied' types, can be measurably increased if carried on within a framework of common understandings" (p. 258).

WILSON D. WALLIS

COMMUNITY AND ENVIRONMENT. *A discourse on social ecology.*

By E. A. Gutkind. Philosophical Library, New York. $3.75. xiv + 81 pp. 1954.

Social Ecology, according to the author, should systematically select the "really instrumental forces which shape man's social aspirations and transform his en-

vironment accordingly." The burden of the argument is that it is high time for such a synthesis aiming at Wholeness. "Man and environment are one," and hence we need a new framework of ideas to guide research on a truly scientific basis. "The field of sociological studies should not only be greatly extended but above all merged into the larger context of ecological relations. On the other hand, it should be concentrated on the investigation of the points of convergence where man and environment, man and group, and man and man can cooperate." Thus, the ecological concepts of gradients of environment, ecological succession, and communities at different times (sic) could be helpful to Social Ecology. The reader may judge the originality and value of these ideas for himself—but it does seem hard to justify the consumption of 80 pages and the expense of an elaborate format to say them.

BENTLEY GLASS

SCIENCE AND SOCIAL ACTION. *Josiah Mason Lectures delivered at the University of Birmingham.*

By W. J. H. Sprott. The Free Press, Glencoe. $3.50. viii + 164 pp. 1955.

This book presents the Josiah Mason Lectures delivered in 1953 at the University of Birmingham. The emphasis throughout, as indicated by the title of the series, is placed on social action, since the author follows Max Weber in considering this to be the key concept of the social sciences.

The first chapter, The Nature of Social Action, deals with the central position of this concept in the study of society. The second, Personality, Society, and Culture, treats four aspects of action: interaction; the social constructs within which it occurs; some beliefs related to it; and the environment in which it takes place. The third chapter, The Scientific Approach, criticizes both the diversity and the lack of organization of past and present endeavors in social study; it relates these characteristics to a lack of social theory, and advocates the desirability in the future of carrying out such studies against a broader theoretical background than in the past. The next three chapters consider in turn The Small Group, Assimilation, and Deviance viewed from a wide perspective. The ensuing chapter, The Grand Manner, perhaps the most interesting and illuminating in the series, returns to the general problem raised in Chapter III, and attempts to establish some general rules of historical development. These are applied, in the final chapter to The Sociology of Knowledge, relating cognitive systems historically and dynamically to the social systems in which they develop.

The volume shows in its content a judicious balance between fact and theory. It is well-written, and both thoughtful and thought-provoking. It deserves a large audience among biological scientists.

JANE OPPENHEIMER

KRIMINALBIOLOGISCHE GEGENWARTSFRAGEN. *Vorträge bei der VII. Tagung der Kriminalbiologischen Gesellschaft May 28 and 29, 1953 in München.*

Edited by Edmund Mezger and Ernst Seelig. Ferdinand Enke Verlag, Stuttgart. DM 17.—(paper). xii + 126 pp. 1953.

These proceedings include 7 papers on the judicial handling of sex delinquents (Kretschmer, Seelig, Hirschmann, Württenberger, Wagner, Langelüddeke, and Rommeney), 3 papers on problems of legal responsibility (Mezger, Gruhle, and Tumlirz), and 3 papers on problems of negligence, e.g., responsibility for traffic accidents under the influence of alcohol (Nowakowski, Hartung and Laves).

BIOMETRY

STATISTICAL METHODS FOR THE BEHAVIORAL SCIENCES. *By Allen L. Edwards. Rinehart & Company, New York.* $5.50. xviii + 542 pp.; ill. 1954.

For students of biology and psychology who find the customary textbooks of statistical methods difficult and laborious, this clearly written and self-contained treatment would seem to be just the thing. It begins on an exceedingly elementary level, with a review of the necessary mathematics from symbols, fractions, decimals, and percentages to operations of various sorts, exponents, logarithms, and equations. The exposition of statistics begins with a study of measures of central tendency and variation, followed by a chapter of short-cuts in the computation of laborious items such as sums of squares. A consideration of the graphical representation of frequency distributions and the use of standard scores and normalizing distributions is followed by linear regression and the product-moment correlation coefficient. Then, in order, come chapters on: Random Errors of Measurement; Point Coefficients and Other Measures of Association; Probability and the Binomial Distribution; The Normal Distribution; The *t* Test for the Means of Independent Samples; The Difference between the Means for Paired Observations and Equated Groups; The Significance of Correlation and Regression Coefficients; The Analysis of Variance; Further Applications of the Analysis of Variance; The χ^2 Test of Significance; and Significance Tests for Ranked Data. Each chapter contains an adequate series of examples, but these are drawn from the field of psychology rather than biology. Fifteen adequate tables, answers to the examples, and author and subject indexes complete the book. On account of its

clarity and comprehensiveness it is highly recommended.

BENTLEY GLASS

BIOMATHEMATICS. *The Principles of Mathematics for Students of Biological Science. Being the Third Edition and a Rewritten Version of the Work by the Late W. M. Feldman.*

By Cedric A. B. Smith. Hafner Publishing Company, New York. $13.50. xvi + 712 pp.; ill. 1954.

Biomathematics was especially written for biologists who need an extracurricular guide to the basic tools of mathematical analysis, but there is no reason (except its price) that it should not serve as a provocative textbook as well. It covers about a year's college course, reviewing adult arithmetic, algebra, geometry, trigonometry, the calculus series and elementary differential equations from the viewpoint of the special interests of biologists. There are also introductions to vectors, matrices and probability distributions. A final chapter concerns "Colson notation, arithmetic made easy" which is a formalization of some old calculating machine tricks. This would have been an opportune place to mention other numerical systems, e.g., binary notation, which are potentially important in biomathematical notation. The book emphasizes practical applications, with examples from biology, and quasi-rigorous demonstrations are offered only when the student's understanding of the application would require them.

Although many other books cover the same topics with equal authority, there are few as suitable for self-study. The nearest parallel, as was pointed out already in the earlier editions of *Biomathematics*, is Mellor's well-known *Higher Mathematics* recently issued as a reprint. This seems rather old-fashioned and formidable in comparison with *Biomathematics*, and the latter is written in a more expansive and far more entertaining style. On these grounds, Mellor's book might be recommended as an expedient and inexpensive refresher course, while that of Smith would be more appropriate for self-study.

J. LEDERBERG

STATISTICS IN RESEARCH. *Basic Concepts and Techniques for Research Workers.*

By Bernard Ostle. The Iowa State College Press, Ames. $6.95. xiv + 487 pp.; ill. 1954.

This textbook was used as the basis of a course given in the Department of Statistics at Iowa State College for several years, and is intended to provide a description of the principal statistical methods of use to workers in all areas of scientific research, as well as to facilitate the teaching of statistics. Its aim and origin make it interesting to compare it with Snedecor's widely known book, *Statistical Methods*, which derives from the same institution.

The contents sufficiently illustrate the author's approach. The book opens with a consideration of the role of statistics in research. Next the basic statistical concepts are introduced, followed by measurement data and random sampling distributions (t, F, etc.). A chapter on Chi-Square, the Poisson distribution, and tests of goodness of fit leads to a consideration of the mean and variance of normal populations. Regression analysis with one variable, correlation methods, and regression analysis with two or more independent variables come next, and are followed by several meaty chapters on the analysis of variance (completely randomized design, randomized complete block and Latin Square designs, factorials, etc.). The analysis of covariance and other statistical techniques related to variance analysis leads to a final chapter on the Design of Experimental Investigations. Tables, a list of references, and an index complete the volume.

The difficulty of the text is about equal, it would seem, to that of Snedecor's book and the coverage is not too different. It might almost be regarded as a new edition, fairly extensively rewritten, of the latter.

INTRODUCTION TO MATHEMATICAL STATISTICS. *Second Edition.*

By Paul G. Hoel. John Wiley & Sons, New York; Chapman & Hall, London. $5.00. xii + 331 pp.; ill. 1954.

In response to suggestions and criticisms directed toward the first edition of this generally excellent textbook (*Q. R. B.* 23: 406. 1948), the author has undertaken a fairly extensive reorganization of the material. A chapter on probability has been added for those unfamiliar with the elements of probability theory. The basic concepts of elementary statistical theory are introduced earlier and have been treated more thoroughly. Regression has received greater emphasis, and consideration of the analysis of variance and of nonparametric methods has been expanded considerably. Additional practice problems have been added. The book is directed principally to science majors who have an adequate mathematical background, and should prove increasingly useful.

STATISTICAL ANALYSIS IN CHEMISTRY AND THE CHEMICAL INDUSTRY.

By Carl A. Bennett and Norman L. Franklin; sponsored by The Committee on Applied Mathematical Statistics, The National Research Council. John Wiley & Sons, New York; Chapman & Hall, London. $8.00. xvi + 724 pp.; ill. 1954.

It is of some interest to compare the contents of the

present work with those of a statistical text designed for biologists or for all scientists. This volume contains 11 chapters, as follows: Introduction; Descriptive Statistics; Probability and Samples; Mathematical Machinery (by which is meant distribution functions, moments and generating functions, the normal distribution and sampling from it, and discrete probability distributions); Statistical Inference; Relationship between Variables; Analysis of Variance; The Design of Experiments; Analysis of Counted Data; Control Charts; and Some Tests for Randomness. The text is pitched at a somewhat higher level of mathematical sophistication than Snedecor's *Statistical Methods* or Ostle's *Statistics in Research* (see above), and will require a good command of college algebra and calculus on the part of its users. It is definitely not for the novice.

DECISION PROCESSES.

Edited by R. M. Thrall, C. H. Coombs, and R. L. Davis. John Wiley & Sons, New York; Chapman & Hall, London. $5.00. viii + 332 pp.; ill. 1954.

This lithoprinted volume is the outgrowth of a seminar on The Design of Experiments in Decision Processes which was held in 1952, the lateness of the date of publication arising from the fact that the 25 contributors were allowed time not only to revise manuscripts but actually to complete studies which were in progress at the time of the conference and were reported there in preliminary form. The book is not intended to be a definitive work, but rather to raise a number of basic questions and to suggest ways in which answers may be sought.

Following an Introduction (R. L. Davis) and a paper on Mathematical Models and Measurement Theory (C. H. Coombs, H. Raiffa, and R. M. Thrall), the remainder of the volume is divided into four parts dealing respectively with Individual and Social Choice (5 papers), Learning Theory (3 papers), The Theory and Applications of Utility (5 papers), and Experimental Studies, the latter on Tendencies toward Group Comparability in Competitive Bargaining, On Decision-Making under Uncertainty, Environmental Non-Stationarity in a Sequential Decision-Making Experiment, and on Some Experimental n-Person Games. The book will be chiefly of interest to psychologists and biostatisticians.

THEORY OF GAMES AS A TOOL FOR THE MORAL PHILOSOPHER.

By R. B. Braithwaite. Cambridge University Press, New York. $1.25. 75 pp.; ill. 1955.

THEORY OF GAMES AND STATISTICAL DECISIONS.

By David Blackwell and M. A. Girshick. John Wiley & Sons, New York; Chapman & Hall, London. $7.50. xii + 355 pp.; ill. 1954.

Each new development in physics and mathematics raises hopes for its potential application to biology. Usually such applications present insurmountable difficulties and it is not likely that the theory of games will prove an exception. Braithwaite does raise an interesting problem: how may "people with different aims . . . collaborate in common tasks so as to obtain maximum satisfaction compatible with fair distribution. . ." This problem is rather like a fundamental theoretical problem in biology: Is the organism well designed? In every adjustment to change, different homeostatic systems, having different aims, reach a compromise. Is this a good compromise? It has never been possible to ask this question in a very clear fashion because it has never been possible to assign values of a comparable sort to the goals of various homeostatic mechanisms. How shall we compare the cost of maintaining a respiratory mechanism of variable capacity and the cost of putting this mechanism into increased activity when blood CO_2 rises, with the presumptive cost to the organism of not having such a mechanism and functioning at times under less than optimal CO_2 levels? Braithwaite offers a tentative approach to such problems in terms of the theory of games. He has devised a method in which values appear on a scale with arbitrary zero and arbitrary unit and may in spite of this be compared. It is entirely possible that this approach could prove fruitful in the hands of a theoretical biologist, enabling him to answer the question "What were the values?" from the solution or actual compromise made by the organism, or to answer the inverse question, assuming a scale of values, "Was the organism's solution a good one?"

The work of Blackwell and Gershick is a rather advanced mathematical treatment of the theory of games. It is not an introduction but rather a systematic and rigorous development of theorems and results at the level of elementary real variable theory (which is not very elementary).

PAUL CRANEFIELD

CLINICAL VERSUS STATISTICAL PREDICTION. *A Theoretical Analysis and a Review of the Evidence.*

By Paul E. Meehl. University of Minnesota Press, Minneapolis. $3.00. x + 149 pp. 1954.

A surprising book, this is a defense of the value of clinical intuition in making predictions, as superior to the usual statistical approach to prediction. The application is to psychology, psychometrics, and psychiatry. The author agrees that the use of statistics is unavoidable—he wishes only to place clinical observations in their rightful place as a basis for making inferences from class membership and for drawing valid empirical conclusions. A brief chapter considers common errors

and misconceptions in the quantification of clinical material.

DE OMNIBUS REBUS ET QUIBUSDAM ALIIS

CARNEGIE INSTITUTION OF WASHINGTON YEAR BOOK No. 53. *July 1, 1953–June 30, 1954, with Administrative Reports through December 10, 1954.*

Carnegie Institution of Washington, Washington. $1.50 (cloth); $1.00 (paper). xxxx + 311 pp. + 8 pl.; text ill. 1954.

Besides the usual business reports of the Carnegie Institution of Washington, this volume contains the annual views and previews of the work of the four departments of Astronomy, Terrestrial Studies, Biological Sciences, and Archaeology. While biologists have learned to scan these reports eagerly for advance publication of the important work done by Carnegie biologists in plant physiology and ecology, genetics, and embryology, it is especially desirable to direct their attention also to the work by Philip H. Abelson of the Geophysical Laboratory on the occurrence of amino acids in fossils. Highly interesting studies on the thermal degradation of alanine signify that possibly a "geological thermometer" for sediments can be developed.

The more strictly biological studies at the other departments include work on the experimental taxonomy of *Poa*, *Mimulus*, and the Lemnaceae; the physiology and evolution of climatic races; nucleic acid and protein studies of nuclei; biochemical investigations related to photosynthesis; mutation in *Chlamydomonas*; the paleobotany of the Tertiary conifers; studies of early human embryos; the structure and physiology of the uterus and placenta in various mammals; and the physiology of the male reproductive tract and seminal fluid. Probably the most widely known program is that in genetics, as represented by studies of growth and inheritance in bacterial viruses, of pseudoallelic relations in bacterial genetics, of the organization of cellular, and particularly of nuclear, materials, and finally of mutations and "controlling elements" in maize and chromosomal aberrations in *Neurospora*. In this area some of the most exciting and original modern work in biology is being accomplished.

BENTLEY GLASS

SCIENCE IN ALASKA, 1952. *Proceedings Third Alaskan Science Conference, Mt. McKinley National Park, Sept. 22–27, 1952.*

American Association for the Advancement of Science, Washington, D. C.; [Alaska Division, Juneau]. $3.00 (paper). vi + 221 pp.; ill. 1954.

The 3rd Alaskan Science Conference, held in 1952 under the auspices of the AAAS, indicated the vitality of research going on in institutions in Alaska and Canada. The activities discussed at the conference cover most phases of the biological and physical sciences, together with some areas of engineering and the social sciences. The papers are included in this volume in abstract form.

DIRECTORY OF HYDROBIOLOGICAL LABORATORIES AND PERSONNEL IN NORTH AMERICA.

Edited by Robert W. Hiatt; with the co-operation of Arthur D. Hasler, Carl L. Hubbs, Daniel Merriman, William E. Ricker, and William Randolph Taylor. Prepared under the Auspices of the Advisory Committee on Hydrobiology to The Office of Naval Research. University of Hawaii Press, Honolulu. $3.75. x + 324 pp.; ill. 1954.

This volume was prepared under the auspices of the ONR Advisory Committee on Hydrobiology for the purpose of providing up-to-date information on the current trends and needs in the various fields of hydrobiology. This has been done by listing the laboratories, both marine and fresh-water, and the personnel and facilities available. Under each laboratory the following information is provided: year established, address, senior officer, objectives, scope and period of activities, environment stressed and available, provisions for temporary investigators, instructional program, major research and teaching facilities, financial support and provisions for publication. Under personnel, arranged alphabetically, addresses and principal areas of activity are provided.

SCIENCE THE SUPER SLEUTH.

By Lynn Poole, illustrated by Clifford N. Geary. Whittlesey House, McGraw-Hill Book Company, New York, Toronto, and London. $2.75. 192 pp.; ill. 1954.

Mr. Poole is known to a wide TV audience as the director and commentator of The Johns Hopkins Science Review as well as of successor programs. Out of his varied experience has come a series of books for teen-agers on various aspects of modern science and adventure. The assembling of these books, however, involves more extensive coverage than that included in the TV programs, and a good deal of research has been necessary to fill in the many gaps, and to complete the story. The result, in this instance at least, is a somewhat disjointed tale, but one nonetheless that conveys in readable fashion the methods and tools of science used by the police in the solution of crime. Since only successes are described, the reader gains no impression of the extent to which science has aided the

criminologists; he only knows that a murderer is sometimes hung by a slender blonde hair or tripped up by a grain of sand out of place.

SCIENCE IN OUR LIVES.

By Ritchie Calder. Michigan State College Press, East Lansing. $3.00. vi + 186 pp. 1954.

Also *Signet Key Book* edition. *The New American Library, New York.* 35 cents (paper). 192 pp. 1954.

This is graphic, popular science writing at very near its best. Calder has learned, for one thing—what a great many American science writers have not yet discovered for themselves—that the history of science and discovery can be as absorbing as any science fiction thriller. He is deeply concerned not only with the fruits of science and its social impact, but equally with the methods of science and its relation to education. The book is consequently outstanding, and particularly so because the author's acquaintance with science and with scientists is one of long standing and personal participation.

Biology is represented here by the now familiar stories of the discovery of penicillin and other antibiotics, of the sulfa drugs—and going back to an earlier period—the effort of Paul Ehrlich to find a potent drug against the spirochete of syphilis. The impact of the growth of human populations is the theme of another section, which deals with the Malthusian problem and the declining fertility of the land, with the war on pests, animal breeding potentialities, and reclamation of desert and jungle. This book should profoundly deepen the understanding of science on the part of those who read it. May those be many, and may there be many more such books to follow it.

BENTLEY GLASS

CAREERS AND OPPORTUNITIES IN SCIENCE. *A Survey of All Fields.*

By Philip Pollack; introduction by Harlow Shapley. E. P. Dutton & Company, New York. $3.75. 252 pp. + 16 pl. 1954.

The young student, as always, faces a decision of major proportions when he attempts to appraise the opportunities which lie ahead of him and the hurdles which stand in his way. This volume, written for the high school student about to enter college, is an attempt to reveal to the interested boy or girl the areas of science which are the most challenging at the moment in that they offer an opportunity for creative work and rapid advancement. The book has an opportunistic air about it, and it is inevitable that certain areas are overlooked or minimized just as others are overemphasized, but the one serious drawback of the book, at least to the reviewer, is the lack of space given to the opportunities in the teaching of science. What little is said of teaching is more likely to drive away than to attract the young scientist.

THE GIANT ANTHOLOGY OF SCIENCE FICTION. *10 Complete Short Novels.*

Edited by Leo Margulies and Oscar J. Friend. Merlin Press, New York. $3.95. xii + 580 pp. 1954.

In spite of the title, only one of the ten stories in this volume can be classified as science fiction. The rest belong in the category of fantasy, that is to say, they are not based on an extrapolation of known scientific facts and principles. All but one of these stories are relatively recent. The exception was first published in 1919. All of the pieces are unusually long, averaging over twenty thousand words apiece. While many fine authors are represented, such as Kuttner, Brown, Williamson, and van Vogt, the stories are definitely not representative of their best work. The recent demand for science fiction anthologies seems to have exhausted the supply of first-rate stories, leaving the anthologist no choice but to use either second-rate and fantasy stories, or stories which have already appeared in book form. Of the present collection, only one story falls into the latter category, a fact which by itself recommends this volume to collectors.

M. A. BENDER

THE BOMB, SURVIVAL AND YOU. *Protection for People—Buildings—Equipment.*

By Fred N. Severud and Anthony F. Merrill. Reinhold Publishing Corporation, New York. $5.95. 264 pp.; ill. 1954.

A study of the types of building construction needed for protection against atomic bomb explosions, written by an engineer and a journalist—primarily of interest to architectural engineers.

THE INDEX
TO THIS VOLUME HAS BEEN REMOVED
FROM THIS POSITION AND PLACED AT
THE BEGINNING OF THE FILM FOR
THE CONVENIENCE OF READERS.

THE QUARTERLY REVIEW OF BIOLOGY publishes critical reviews of recent researches in all of the special fields of biological science. The contribution should present a synthesis or digest of the researches and a critical evaluation of them. A mere synopsis of the literature without evaluation or synthesis is not desirable.

Theoretical papers are published occasionally, especially when such papers (1) include a critical synthesis of the literature bearing on the theory and (2) are likely to promote further research in a given field.

The article should be written in concise language, yet in sufficiently non-technical form as to be intelligible not only to specialists in other fields but to the general biologist as well. To this end the article should have a general introduction and a summary which enumerates one by one all of the principal facts and conclusions given in the paper. Interpretative diagrams and schemes are very desirable.

Material ordinarily taking the form of footnotes is set in small print and placed in the text and consequently should be written in a style so as to fit readily into the text. Acknowledgments are printed in the text in small type at the end of the article just preceding the List of Literature. Recent issues of the Quarterly should be examined for style as regards (1) section or subsection headings in the text, (2) literature citations in the text, and (3) List of Literature.

The subjects and authors of articles are selected by the Editors and members of the Advisory Board. Unsolicited articles which conform with the objectives of the Quarterly will be considered for publication.

A feature of the REVIEW is the section dealing with *New Biological Books*. In this department the book literature of different countries in the field of Biology is given prompt notice.

The QUARTERLY REVIEW OF BIOLOGY is issued in March, June, September and December.

Twenty-five reprints, with covers, of articles will be furnished to contributors free of cost. The reprint order blank accompanying galley proofs gives the cost of additional reprints.

Manuscripts may be sent to Dr. B. H. Willier, Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland.

Books for Review may be sent to Dr. H. B. Glass, Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland.

New subscriptions and renewals are entered to begin with the first issue of the current volume. Should any issue of the current volume be out of print at the time the subscription order is received, the pro-rata value of such numbers will be refunded to the subscriber.

Subscriptions should be renewed promptly—To avoid a break in your series, subscriptions should be renewed promptly. The publishers cannot guarantee to supply back issues on belated renewals.

Subscription price: $6.00 United States. Countries within the Postal Union and foreign countries, $6.75; Canada, $6.25. Single copies will be supplied, when available, at the rate of $1.75 a copy, plus $.25 postage outside USA.

Claims for copies lost in the mails must be received within 30 days (domestic).

Change of address—Publisher must be notified 60 days in advance. Journals undeliverable because of incorrect address will be destroyed. Duplicates can be obtained (if available) from the publisher at the regular price of single issues.

THE WILLIAMS & WILKINS COMPANY

Publishers of Scientific Books and Periodicals

BALTIMORE, U. S. A.

THIS NUMBER COMPLETES VOLUME 31

CONTENTS

Cell Division. Part Two: A Theoretical Approach to Chromosomal Movements and the Division of the Cell —*Norman G. Anderson* (243–269)

Evolution and Bioluminescence —*E. Newton Harvey* (270–287)

New Biological Books
Reviews and Brief Notices (288–349)

Index (351–360)